EFFECT OF PHOSPHATIC FERTILIZER COMPOUNDS ON AQUATIC PRIMARY PRODUCTION IN SALINE WATER

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Dedicated to:

My father Sri.K.K.Nair

&

My mother Smt.B.Indiradevi

Without whose support and inspiration

this would not have been possible

DECLARATION

I hereby declare that this thesis entitled **"EFFECT OF PHOSPHATIC FERTILIZER COMPOUNDS ON AQUATIC PRIMARY PRODUCTION IN SALINE WATER "** is a bonafide record of research work done by me during the course of research and that the thesis has not formed the basis for the award to me of any degree, diploma, associateship, or other similar title, of any other University or Society.

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Introduction

1.INTRODUCTION

Fertilizers are applied to culture systems to increase plant nutrient concentrations and stimulate phytoplankton growth. The most common fertilizers used in aquatic systems are of phosphorus and nitrogen. Chemical compounds used in fertilizers are usually water soluble (Boyd and Tucker, 1998). In many water bodies the nutrient phosphorus is often found to be below the minimum concentrations required for optimal productivity of the system. One of the reasons for this is the presence of calcium, which forms insoluble calcium phosphate compounds, causing a decrease in the amount of water soluble phosphorus (Chattopadhyay and Ghosh,1976). Another reason for this decreased availability of inorganic phosphorus is the formation of complexes by iron and aluminium (Stumm and Morgan, 1970). Thus the application of phosphatic fertilizers has received major attention in the area of aquaculture for increasing the productivity of culture waters.

Fish production depends on the primary productivity in the aquatic environment. Phosphate is considered as the limiting nutrient in aquatic primary production, because even though other nutrients are available in plenty, the low level of available phosphate is found to limit the primary production on many occasions. Improving the nutrient effect of phosphatic fertilizer can bring about increased primary production. The productivity of culture waters can be enhanced if we have a good knowledge about different phosphatic fertilizers and their desired levels of application for optimum production.

1.1 Primary productivity

Phytoplankton is the predominant type of plant found in most aquaculture ponds. As such, phytoplankton communities are an essential component of most pond aquaculture systems. Primary production by phytoplankton is the base of the food web that supports finfish or shellfish production. Most water quality problems in aquaculture ponds are the result of unwanted growth of phytoplankton communities. Excessive abundance of phytoplankton can lead to reduction of dissolved oxygen. The phytoplankton consists of diatoms ,dinoflagellates and nanoplankton which dominate the net phytoplankton throughout the world. Minor constituents of the phytoplankton include the blue-green algae, the cocolithophores and the silicoflagellates (Nybakken, 1982).

Phytoplankton use chlorophyll and other light absorbing pigments to absorb solar energy and convert it to the chemical energy. The chemical energy thus produced is used to reduce inorganic carbon like carbon dioxide to organic carbon. The process is called photosynthesis and the complex reactions involved in the process can be summarized by the following equation .

$$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

Free oxygen forms one of the byproducts of carbon assimilation. The process therefore becomes a source of dissolved oxygen in the water (Sverdrup *et al.* 1942). Carbondioxide is sufficiently available at all times in fish culture waters either as a dissolved gas or as a raised constituent in the form of bicarbonates, so as to meet the requirements of the plants. It is therefore not a limiting factor in phytoplankton production.

Photosynthesis is the source of organic matter, which serves as food matter in aquaculture ecosystems. The sugars produced in photosynthesis are used in other plant biosynthetic pathways to produce all the other organic compounds needed for the plant to grow. The plant must do biological work in order to grow and reproduce. The energy for doing this work comes from the organic matter produced during photosynthesis. Thus the organic matter produced in photosynthesis is both a source of building blocks for plant biomass and a source of energy. The process whereby plants use energy from organic compounds to do biological work is called respiration and respiration is the reverse of photosynthesis. Respiration can be summarised as

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$$

The primary production is generally understood as being the amount of organic matter produced by the phytoplankton under a unit area of water surface or in a unit volume of water during a given period of time.

1.2 Nutrients and Primary production

The primary production is mainly dependent on two major factors like sunlight and nutrient availability in addition to the presence of phytoplankton (Sverdrup *et al.*, 1942., Polat and Piner, 2002). Phytoplankton population growth becomes limited due to the lack of nutrients like phosphorus and nitrogen. Nutrient deficiency causes significant qualitative changes in phytoplankton composition (Finenko,1978). Primary producers in fish culture waters require certain micro nutrients for their growth. The most important among them are phosphorus, nitrogen and silicon (Millero and Sohn,1992) Many of the nutrients are minor constituents of water, present only in very low concentration and their supply exerts a dominant control over production. The most important nutrients are compounds of nitrogen and phosphorus (Ignatius 1995). Nutrients like phosphorus and nitrogen are known to limit organic production in almost all types of aquatic environment (Rajagopal 1974). The nutrients, particularly nitrogen and phosphorus indicate the fertility of water to promote productivity. Phytoplankton give the production at the primary stages of the food chain, while zooplankton and fish at the secondary and tertiary levels of food chain respectively (Qasim, 1977). The nutrient status of water and soil play the most important role in the primary production in fishponds (Banerjea, 1967).

Phosphorus and nitrogen primarily occur as phosphate and nitrate respectively. Silicon is critical for the proper growth of diatoms but is rarely limiting in aquaculture systems. Addition of the limiting nutrient will stimulate primary productivity until some other nutrient becomes limiting or the supply of the nutrient just added is exhausted (Stickney 1979). Vegter and Visscher (1987) discussed the influence of nutrient concentrations on the phytoplankton primary production. In most estuarine environments competition for assimilable nutrients is intense among various plant and algal species and ecological groups, and also between bacteria and algae (Day et al, 1989). Primary productivity can be estimated by various methods like spectrophotometry, light and dark bottle method and carbon-14 method (Strickland and Parsons, 1972).

1.3 Fertilizers

Substances that increase nutrient concentrations to enhance plant growth are called fertilizers or manures. The term manure is usually used for natural organic substances like animal excreta and agricultural byproducts used as fertilizers. Relatively purified compounds that contain nitrogen, phosphorus, potassium or other nutrients are called as fertilizers. Several studies have shown that yields of fish or shrimp could be increased by fertilizer application in culture waters (Johnson, 1954: Rubright *et al*, 1981 Garson *et al*, 1986). An increasing understanding of the nutrient dynamics in culture waters have led to various fertilization practices which result in substantial increase in aquaculture productivity(Lanhai and Yakupitiyage, 2000).

Fertilizers increase the productivity of a pond by increasing the phytoplankton production which in turn promotes the zooplankton and then the macrobenthic organisms that enter in the natural feeding of prawns (Lumare *et al.* 1985). Phosphate fertilizers have been used by many investigators for raising production of fish in ponds (Jhingran, 1991). Phosphorus plays pivotal role in many vital biochemical reactions. it is a component of energy storing compounds like ATP, ADP etc, it is also essential for the synthesis of phospholipids, enzymes, nucleic acids etc.

Chemical compounds used to fertilize ponds are identical to those used to fertilize agricultural crops. Nitrogen, phosphorous and potassium are termed as the primary nutrient elements of fertilizers. The grade of a fertilizer is usually referred to as percentages by weight of nitrogen (as N) phosphorous (as P_2O_5) and potassium (as K_2O). For aquatic systems, the sources of primary nutrients in fertilizers are relatively simple compounds that dissolve to give nitrate, ammonium, phosphate or potassium ions. Traces of minor nutrients such as copper, zinc, boron, manganese, iron, cobalt and molybdenum are also added in minute amounts in some fertilizers (Boyd and Tucker, 1998).

1.4 Phosphatic fertilizers

Even when other nutrients are available in plenty, the low level of available phosphate is found to limit primary production on many occasions. So the addition of phosphatic fertilizers can bring about increased aquatic production. Phosphatic fertilizers can be broadly classified under two major heads , namely natural and synthetic(Sauchelli,1965).

The major natural phosphatic fertilizers used in fertilization practices are rock phosphate (phosphate rock), phosphorite deposits, bone meal (bone phosphate of lime), guano (excreta of seabirds, bats, and seals) and biofertilizers (bacteria, fungi and cynobacteria). The major synthetic phosphatic fertilizers used in fertilization practices are phosphoric acid, single super phosphate, triple super phosphate, and ammonium phosphates (Collings, 1955). Choosing the right fertilizer and its proper dose will help the farmer to avoid excess fertilizer applications and thereby prevent algal blooms and consequent pollution.

1.5 Objectives

The present study attempts to compare the relative efficiency of three phosphatic fertilizers suitable for saline water fish farms. The study may help to identify the right one among them, the study also aims at fixing the effective dose. The effect of fertilizer additives on enhancing the primary production is also investigated. The farmer may be able to select a cost effective fertilizer to get good production, this in turn can improve the total fish production.

Review of Literature

2.REVIEW OF LITERATURE

2.1 Nutrient phosphorus and primary production

Phosphorus is one of the most important major nutrients that is required by the biota. In comparison with other major elements (eg carbon, hydrogen, nitrogen, oxygen and sulphur) it is required in very small amounts but very often it limits the biological productivity in an ecosystem (Reddy 1997). Phosphorus usually combines with a number of ions in water .The most common among this is calcium ion with which it form calcium phosphate and thus it become unavailable to phytoplankton (Reddy 1997). Thus phosphorus is fixed.

Large amounts of phosphates are found entering the natural water bodies through detergents, it may cause a condition known as eutrophication as a result of which certain species of algae like *Anabaena*, *Oscillatoria*, *Microcystis* etc will form nuisance to aquaculture operations (Boyd and Tucker,1998). Megard (1972) conducted a study on the relationship between phytoplankton photosynthesis and phosphorus in lake Minnetonka and concluded that when *Anabaena*, a nitrogen fixing algae forms an important component of the phytoplankton, there was a positive linear relationship between phosphorus and chlorophyll. Munawar and Burns (1976) conducted studies on the relationship of soluble nutrients and primary production in lake Erie and found that in spring and summer there is a positive correlation between primary production and phosphorus.

Anzari and Rajagopal (1974) have studied the phosphorus cycle in fish farms. Maskey and Boyd (1986) recommended continuous but split doses of phosphate application to fish ponds for good production. Jhingran (1991) observed that phosphorus is the most important nutrient element in the maintenance of productivity in ponds. Phosphorus is often considered as one of the critical factors in the maintenance of biogeochemical nutrient cycles in fish ponds. Deficiency of phosphorus can lead to retardation of phytoplankton growth ultimately leading to decreased productivity in the system

(Chattopadhyay and Ghosh,1976). Clarke *et al* (1988) through their studies found that phosphorus is a limiting nutrient in many lakes and excessive phosphorus fertilization can result in eutrophication.

While discussing water quality, in relation to fish production in aquaculture, Boyd (1982) stated that the ability of water to produce plankton depends on many factors but the most important was usually the availability of in-organic nutrients like carbon, oxygen, hydrogen, phosphorus, nitrogen, potassium etc. Out of this phosphorus is, most often, the element regulating phytoplankton growth in ponds. Phytoplankton requires an adequate quantity of phosphorus for primary production. A total phosphorus range of 0.05-0.4ppm in freshwater and 0.05-0.5ppm in brackish and seawater are considered ideal for aquaculture operations (Reddy 1997). Eutrophication of water bodies is often correlated with the amount of phosphorus present in aquatic environment (Reddy 1997). Sorokin (1983) studied the rate of inorganic phosphate uptake by bacterioplankton and phytoplankton. He established a close correlation between phosphate consumption and primary production and found that along with increasing phosphate consumption there is an increase in the primary production also. During studies on the nutrient limitation of plankton production, Stross (1980) found that increase in phosphate content increased the photosynthetic capacity of plankton..

According to Seymour (1980) increase in the natural level of nutrients, especially of phosphorus is essential for activating trophic chains. Banerjea(1967) studied the water quality and soil condition of fish ponds in some states of India in relation to fish production and found that out of 22 ponds with dissolved phosphorus less than 0.05ppm, one was productive, 5 of them average and 16 unproductive. Out of 25 ponds with phosphate in the range 0.05-0.1ppm, 5 were productive, 13 average and 7 unproductive. In the range 0.1-0.2 ppm , out of 14 ponds 5 were productive ,5 average and 4 unproductive. From this it may be concluded that dissolved phosphorus less than 0.05ppm can be considered insufficient, while in the range 0.05-0.2ppm medium to high production can be expected. If very good production is needed, then the fish ponds should have a phosphorus concentration above 0.2ppm of phosphate-P. Saha *et al.* (1971) studied the seasonal and diurnal variations in physicochemical and biological conditions of a perennial freshwater pond in Cuttack, Orissa and obtained a direct and positive relationship between the seasonal variations of phosphate and seasonal fluctuations of main groups of phytoplankton like *chlorophyceae*, *cyanophyceae* and *diatomaceae*. Sreenivasan and Venkatanarasimha (1979) recorded considerable increase in fish production through super phosphate fertilization.

Among the three forms of phosphorus *viz.*, soluble inorganic phosphorus, soluble organic phosphorus and particulate phosphorus, the reactive soluble orthophosphate is the fraction that is immediately useful for autotrophic plants. The ability of plankton to rapidly absorb phosphate from the water and store it for future use in their cells is well identified (Ignatius, 1995). Plankton can absorb 50% or more of phosphate added in a normal fertilizer application within 24 hours (Boyd and Pillai, 1984). Hydrolysis of polyphosphate results in the production of pure orthophosphate, which is readily utilized by phytoplankton (Grasshoff *et al.*, 1983). Vrede *et al.* (1999) made a seasonal study on the effect of nutrients (phosphorus, nitrogen and carbon) and zooplankton and reported instances of stimulating phytoplankton growth by the application of phosphorus alone.

Eren *et al.* (1977) have done experiments on phosphorus fertilization of fish ponds in the Upper Galillee, Israel to elucidate the chemical and biological mechanisms involved in the P cycle of fish ponds and to evaluate the necessity for phosphorus fertilization. Through their studies they found that a minimum of 0.2ppm of phosphate-P can be considered to be the concentration required for high aquatic productivity. Phosphorus is considered as an important nutrient source in fish culture as it enhances higher primary production than nitrogen alone (Daniels and Boyd, 1993).

Though the inorganic fixation of phosphorus in water and soil is rapid and the phosphorus remains in solution for a very short period only, it is absorbed by phytoplankton during this brief period (Jhingran, 1991).

According to Heath *et al.* (1980), orthophosphate is the limiting factor in aquatic systems for algal growth. Lean *et al.* (1987) during his studies on the plankton of lake Ontario, observed phosphorus deficiency in phytoplankton.

Phytoplankton can take up orthophosphate quickly in a concentration as low as 1mg P/L or less (Rigler 1966). Blue green algae are particularly adept at acquiring and storing phosphorus inside the cells when the nutrient is abundant. Obviously the ability to assimilate and store more nutrient than needed is a competitive advantage because it allows plants to survive brief periods when ambient nutrient levels are low (Kilham and Hecky, 1988). The studies done by Rajagopalsamy *et al.* (1997) confirmed the quantitative removal of soluble inorganic phosphate through phytoplankton assimilation. Studies by Aldridge and Ganf (2003) indicates that one reason for the eutrophication of water bodies is the abundance of the nutrient phosphorus.

Boyd *et al.* (1981) conducted a study on the effect of three phosphatic fertilizers on the phytoplankton densities and concluded that all the three phosphatic fertilizers *viz.,* triple superphosphate, diammonium phosphate and ammonium polyphosphate were effective in increasing phytoplankton abundance. In this study, the maximum chlorophyll values were recorded in the treatment of ammonium polyphosphate(liquid). The treatments diammonium phosphate and triple superphosphate were ranked second and third respectively. Sarkar (1991) studied the effect of a combination of mustard oilcake, ammonium sulphate and superphosphate on fish and aquatic ecosystem and found that the highest fish survival and production were obtained in ponds fertilized with nitrogen and phosphorus at the rates of 60 and 40 kg/ha, respectively along with lime and mustard oilcake. It was also found that at these treatment levels, density of plankton increased significantly. Dhawan and Kaur (2002) studied the effect of pigdung on growth and reproductive potential of *Cyprinus carpio*, and noted that phosphorus and plankton production in the pond was significantly increased by the application of pig dung.

Singh and Sharma (1999) did a comparative study on the effect of three organic manures *viz.*, cowdung, pigdung and poultry excreta on the growth of *Labeo rohita* in fish farms and they found that reasonably good levels of fish production could be obtained by applying organic manures having good phosphorus content. Govind *et al.* (1978) found that the increase of phosphate through the application of poultry and cow dung mixture will stimulate good plankton production.

Padmavathi et al (1997) had described phosphorus as an indispensable nutrient, which is present in lesser concentrations in pond waters to promote abundant phytoplankton growth. In their studies on the impact of nitrogen and phosphorus on brackish water pond fertility and effluent quality and they found that none of the chemical species of phosphorus showed significant correlation with the duration of culture. This observation confirmed that ,besides biological utilization, heavy precipitation of phosphorus occurred in the system, which could have masked the phosphorus input through left out feed, excreta and fertilizers.

Khan and Siddiqui (1974) have done a correlation analysis between phytoplankton number and phosphorus concentration and obtained a negative and significant value ie, r = (-0.84). They concluded that low values of phosphorus during phytoplankton bloom was due to accumulation of phosphorus in the cells of phytoplankton. During the studies by Banerjee and Roychoudhary (1966) in Chilka lake it was found that when the phytoplankton concentration is increasing, the phosphate value showed a decline in concentration substantiating the statement by Khan and Siddiqui (1974). Gupta *et al.* (2001) studied the riverine and estuarine water quality of Dakshina Kannada and Udupi districts of Karnataka and in the natural surface waters of the rivers, they recorded trace levels of nutrient phosphate. Lakshmipathi *et al.* (2000) studied seasonal variations of nutrients in relation to tidal rhythm of Netravathi estuary at the west coast of India and they found that inorganic phosphorus together with various forms of nitrogen determined the productivity of the estuary. Das (2000) studied the limnochemistry of some Andhra Pradesh reservoirs and observed that the concentration of nitrogen and phosphorus were poor in the reservoir waters. Singh and Desai (1980) made limnological observations on Rihand resevoir in U.P and they observed that the nutrient conditions of water played an important role in phytoplankton production. In 1975, the nitrate and phosphate values were high in comparison to 1973 and 1974, but the high turbidity in 1975 hampered the growth of phytoplankton, which led to low production. Average primary productivity was 130.84 $mgC/m^3/day$ in 1975 and during 1973 and 1974 primary productivity of 204.51 $mgC/m^3/day$ and 186.54 $mgC/m^3/day$ were observed.

2.2 Other water quality parameters under study

2.2.1 Nitrogen

Nitrogen being a major nutrient element, plays an important role in determining the fertility of fish ponds. Hence determination of available nitrogen is an important pre-requisite for assessing the fertility status of the culture system. The least desirable form of nitrogen in aquaculture system is nitrite (Prakash, 1997). It originates from the reduction of nitrate by bacteria in the anaerobic mud or water. Denitrification is the reduction process of nitrates in to nitrites, ammonia and finally nitrogen (Reddy, 1997). Thus denitrification occurs in anaerobic conditions (Reddy and Patrick, 1976).

Ammonium ions can be removed from water by uptake by plants, algae and bacteria. Ammonium may also be oxidized by nitrifying bacteria, which is known as nitrification. Nitrification is the oxidation of ammonia into nitrites and nitrates and require oxygen. Nitrate is the principal dissolved form of nitrogen whose relationship with salinity has been studied in estuarine waters. Stefansson and Richards (1963) reported a linear relationship between nitrate and salinity in the estuary of the Columbia river. Anaerobic conditions are required by nitrogen fixers because the enzymes involved in N_2 fixation are sensitive to oxygen. Most blue green algae that fix nitrogen have structures called heterocysts in which anaerobic conditions are maintained and within which fixation may take place even in aerobic water (Valiela, 1984).

Nitrite is routinely found in intensive pond aquaculture systems because large amounts of nitrogen are added in the form of manufactured feed, fertilizer or manure (Boyd and Tucker, 1998). Nitrite may briefly accumulate in water after sudden increase in ammonia concentrations following phytoplankton die-offs or after aquatic weeds are killed with herbicides (Tucker *et al.* 1983).

2.2.2 Silicate

Silica occurs mainly as orthosilicate. Diatoms which constitute a very prominent and strategic group in the plankton (Reddy, 1997). As the growth of diatoms increases amount of silica decreases especially in surface water following diatoms blooms (Reddy,1997). Silica concentration also shows a seasonal variation in ponds (Reddy, 1997).

Concentration of silica in natural waters range from 1-80 ppm ,4-16ppm is ideal for freshwater aquaculture systems, above 5ppm is ideal for brackish and sea water systems (Reddy 1997). Since the diatoms are the main source of food for shrimp larvae, they are cultured under controlled conditions in large cement ponds. In these cultures, silica is added in the form of sodium silicate at the rate of 38ppm and 19ppm respectively in indoor and outdoor cultures (Reddy,1997).

The common aqueous forms of silica are H_4SiO_4 and $H_3SiO_4^-$ (Clesceri *et al*, 1998). In Ecuador, some shrimp farmers apply sodium metasilicate to ponds as a fertilizer for diatoms. However, because of the expense, only small applications are made (0.05-0.1 mg/L as SiO_2), and it is doubtful whether such low concentrations will be effective (Boyd and Tucker, 1998). Silicate fertilization may be beneficial to diatom production in brackish water ponds. Sodium silicate is available commercially, but it is expensive. A fertilizer sold under the trade name Nutrilake is produced by SQM Nitratos of Chile. This fertilizer contains 15% N from sodium nitrate, 3.5% silicate and a variety of trace nutrients. It is being used by many shrimp farmers in central and south America to promote diatom growth in ponds (Boyd and Tucker, 1998).

2.2.3 Iron

Iron can be found in many forms in pond waters. Two of the most common forms are the ferrous (Fe^{2+}) and ferric (Fe^{3+}) ionic states. Ferrous form of iron is soluble in water. The ground water can often contain over 10 mg/L of iron, the anaerobic conditions in the soil will favor the formation of soluble ferrous form of iron, but when the water is removed from the ground and is exposed to air the iron oxidizes to the insoluble ferric form. Iron helps in the proper production of chlorophyll. Most algae grow best in the water having iron in the form of ferric oxide. In natural waters, total iron concentrations are usually 0.05 – 0.2 ppm while for fresh, brackish and sea water a range of 0.01 – 0.3 ppm of iron is an ideal range (Reddy, 1997). In a study in the estuary of the Fraser river Burton (1976) found that plankton assimilated particulate iron and released the element in dissolved forms.

Complex formation involving ferric iron and phosphate anion has significant effect on the phosphate distribution. Adsorption of phosphate on ferric aluminium –oxides or hydroxides is also important in the distribution of available phosphorus (Stumm and Morgan, 1970). In anaerobic sediments bacteria and hydrogen sulphide present will reduce ferric iron to ferrous iron. Ferrous iron is much less affective in adsorbing phosphate than ferric iron and the reduction of iron thus results in the greater availability of dissolved phosphate in anaerobic environments (Krom and Berner, 1980). For pond fish culture, the most simple method to remove iron from water before it causes problems is to pump the water in to a small pond while aerating. The iron will then oxidize to ferric form and precipitate. A one or two day retention time are generally required to oxidise and settle (Lawson, 1995).

2.2.4 Water pH

The pH value expresses the intensity of the acidic or basic character of water. It is defined as the negative logarithm of the hydrogen ion activity. The pH scale is usually represented as numerals ranging from 0 – 14. Conditions become more acidic as pH values decreases and more basic as pH increases. The fertility of aquatic ecosystems is strongly influenced by environmental pH also (Boyd and Tucker 1998).

During day light aquatic plants usually remove CO_2 from water faster than it can be replaced by respiration, and pH increases. During the night CO_2 accumulates and pH declines. The magnitude of the daily fluctuation in pH depends on the buffering capacity (total alkalinity) of the water and the rates of photosynthesis and respiration (Boyd and Tucker, 1998). The initial pH of fish pond waters (before biological activity adds to or removes carbon dioxide from water) is a function of the total alkalinity of the water. After the start of fish culture, the activities of plants, bacteria and animals cause the pH to cycle diurnally (Boyd and Tucker, 1998). Usually high pH in afternoon typically occurs in waters of moderate to high total alkalinity (50 – 200 ppm as $CaCO_3$)and low total hardness (less than 25 ppm as $CaCO_3$). The principal ions in pond waters usually are sodium and bicarbonate. Sodium phosphates are more soluble than calcium phosphates, so more phosphorous may be available to support plant growth in soft waters, leading to higher rates of photosynthesis, which causes the pH to increase rapidly (Wu and Boyd, 1990).

In many waters with high total alkalinity, the pH is not low enough to reduce the amount of inorganic phosphorus for plant growth. Liming is used to improve productivity in low alkalinity waters. The importance of pH in the precipitation of iron from water was shown by laboratory experiments by Fukai and Huynh Ngoe (1988) in which ^{59}Fe was added to water of various pH values and the removal of dissolved iron was monitored by the disappearance of radioactivity from the aqueous phase. For water pH from 4 to 9 an increasing percentage of iron was lost from solution, with approximately 90% of the added iron being removed at pH 7.

2.2.5 Dissolved oxygen

The availability of dissolved oxygen frequently limits the activities and growth of aquatic animals. Water saturated with oxygen contains 20-40 times less oxygen by volume than air. If dissolved oxygen concentrations are consistently low, aquatic animals may lose apatite, or affects growth and will be susceptible to infectious diseases. If concentrations fall to very low levels, the animal may die (Boyd and Tucker, 1998).

Dissolved oxygen concentration in aquaculture ponds are affected by the same process operating in other surface waters. Oxygen is transferred to and from the water depending on partial pressure of oxygen in the water relative to the partial pressure in the air. Respiration removes oxygen and photosynthesis adds oxygen. As such, biological process tend to dominate the dissolved oxygen budget of aquaculture ponds, whereas oxygen transfer between the air and water is usually more important in less fertile surface waters. Oxygen content in the water of an estuary is largely due to absorption from the atmosphere, but it is also strongly affected by biological activity (Reid and Wood, 1976). Some examples of factors that may reduce gross oxygen production and contribute to oxygen supply deficits in fish ponds include reduced solar radiation, reduced light penetration in to the water due to non-algal turbidity, and the poisoning of phytoplankton with herbicides (Smith and Piedrahita, 1988). It is well known that decay of organic matter like un utilized feed, plankton followed by its death and decay are the other major causes of oxygen depletion.

2.2.6 Carbon dioxide

Carbon dioxide is highly water-soluble biologically active gas. Carbon dioxide is produced in respiration and consumed in photosynthesis. Thus the concentration of dissolved carbon dioxide usually varies inversely with dissolved oxygen (Boyd and Tucker 1998). Dissolved carbon dioxide is of interest in aquaculture because it influences the pH of water, it is required for plant growth and its availability may limit primary productivity of some aquatic ecosystem. Carbon dioxide is highly soluble in water but concentration in pure water exposed to air are low, because carbon dioxide is a minor constituent of the atmosphere. Biological activity may however cause significant variation in carbon dioxide concentration (Boyd and Tucker 1998).

Rapid rates of photosynthesis, abundant phytoplankton, bright sunlight and warm water will result in the rapid removal of carbon dioxide. Dissolved carbon dioxide becomes essentially depleted from water on warm sunny afternoons, in ponds with moderate to dense phytoplankton blooms. At night photosynthesis ceases and carbon dioxide from respiration accumulates. Dissolved carbon dioxide concentration in aquaculture ponds usually ranges from 1 mg/L in the afternoons to 5-10 mg/L or more at dawn. The highest concentration of carbon dioxide in aquaculture ponds occur after phytoplankton die-offs. Carbon dioxide accumulates after the death of phytoplankton because rates of photosynthesis are low and large amounts of the gas are produced as the dead plant material decomposes. Concentrations may exceed 20mg/L for several days offer the die off (Boyd and Tucker 1998). Carbon dioxide can be generated by organic decay including feed and plankton.

In sea water, carbon dioxide is present more in the form of bicarbonate and carbonates than as free gas and carbonic acid. This is because seawater contains alkaline radicals. Thus in the mouth of the estuary where the amount of seawater is greater owing to the tidal influx, the amount of carbon dioxide present is correspondingly lesser. In the regions of the estuary, where the influence of fresh water is greater, carbon dioxide concentration varies considerably. When the carbon dioxide concentration is higher, the carbonic acid concentration increases and the pH becomes lower. Thus, during the day, the pH increases because of the utilization of CO_2 for photosynthesis and during the night, it drops. A diurnal cycle is thus evident for carbon dioxide (Nair and Thampy,1980).

2.2.7 Alkalinity

Alkalinity is a measure of the bases that are titratable with strong acid. It can be thought of as the acid neutralizing capacity. In sea water it is primarily due to the presence of bicarbonate, various forms of borate and many other bases in seawater also add to the alkalinity (Valiela, 1984). The benefits due to the presence of ample alkalinity in pond waters include buffering of water against changes in pH , enhanced natural fertility of waters and decreased potential for metal toxicity. The total alkalinity of waters ranges from less than 5 to over 500 mg/L as $CaCO_3$ (Boyd and Tucker, 1998).

The increase in the productivity of the fertilized ponds is related to the greater availability of phosphorous as alkalinity is increased to about 20 mg/L as $CaCO_3$ (Boyd and Tucker, 1998). In saltwater aquaculture, alkalinity is normally sufficient because of the high concentrations of carbonates, ocean water is strongly buffered at about pH 8.2 (Wedemeyer, 2000).

2.2.8 Hardness and Calcium

Total hardness is the sum of the concentrations of selected soluble salts of calcium and magnesium in water. Other divalent cations also contribute to hardness but their concentrations in natural waters are usually low. Calcium is essential for all planktonic organisms being an important cell wall constituent. It also regulates various physiological functions in animals too. Calcium normally occurs in combination with carbonate ions. Calcium as $CaCO_3$ exercises a great influence mostly beneficial up on the physical and chemical qualities of the soil. Calcium improves the texture of soil and helps in the release of phosphorus in to pond water which remain bound in soil, unavailable for pond productivity (Reddy, 1997).

Water having 75-150 ppm of calcium is considered ideal for aquaculture activity. Total hardness (like total alkalinity) is a general indicator of the presence of minerals in water, and as total hardness increases, concentrations of most other substances like Cl^-, SO^{4-}, Ca^{2+}, Mg^{2+} etc (including other essential plant nutrients) tend also to increase. The total hardness of natural waters ranges from less than 5 to over 10,000 mg/L as $CaCO_3$(Boyd and Tucker, 1998). Chattopadhyay and Ghosh (1976) found that calcium form insoluble calcium phosphate compounds causing a decrease in the amount of water soluble phosphorus.

Materials and Methods

3.MATERIALS AND METHODS

In the study two phosphatic fertilizers namely i) a synthetic fertilizer single superphosphate and ii) a natural mineral fertilizer rock phosphate were screened for their fertilizer effects. In addition a combination of single super phosphate and commercial grade trisodium phosphate mixed in the ratio 1:1 and a combination of rockphosphate and trisodium phosphate mixed in 1:1 ratio were also screened. Each one were tested separately in low saline water having a salinity of approximately 10ppt and high saline water having a salinity of approximately 20 ppt. Three concentration levels namely 0.1 ppm, 0.2 ppm and 0.4 ppm as phosphate-P were tried in all sets. All the treatments were done in duplicates. A set of controls without adding phosphatic fertilizer was also run. The experiments were statistically designed using Completely Randomised Factorial Design, in which the treatments are arranged randomly over the experimental units. Each combination was tried in duplicate. Thus the randomization gives every experimental unit in the experimental setup an equal probability of receiving the treatment (Rangaswamy, 1995).

The experiment was done in open yard on an elevated concrete basin, which was protected by net covering to avoid outside disturbances. Inoculums of brackish water plankton were seeded in all the tanks. The tanks were kept exposed to sunlight for 30 days with out any shade. Basic water quality parameters such as alkalinity, hardness, dissolved oxygen, pH, carbon dioxide, iron, calcium, reactive-P, nitrite, nitrate and silicate were determined on 1^{st}, 7^{th}, 14^{th} and 30^{th} days. Chlorophyll and total phosphorus was determined on 1^{st} and 30^{th} day only. All the first day observations were taken before adding the fertilizers. The samples were taken during at 8.30 am. The relation between the type of fertilizer compounds, their dose and primary production was assessed and optimum conditions were drawn out using analysis of variance (ANOVA). The experiment was conducted in the month of December 2004.

3.1 Experimental setup

Experimental site was selected within the campus of the College of Fisheries, Panangad. Site was selected in such a way that there was minimum disturbance and the tanks were exposed to direct sun light throughout the day (Plate.1). Twenty five litre capacity plastic drums having same colour were used for the experiment and the tanks were numbered serially from one to fifty two. Twenty litres of water was used for the experiment. The experimental medium is brackish water having approximately 10 and 20 ppt salinity levels. These salinity levels were prepared by diluting high saline brackish water with low saline pond water. The two levels were referred to as low and high saline in the following sections. The reduction in the volume of experimental medium, due to loss of water owing to evaporation was compensated by adding water with same salinity in every week.

3.2 Estimation of Water quality parameters

3.2.1 Estimation of available phosphorus

Available phosphorus is the inorganic phosphate content of the sample. The available phosphorus was determined by following the standard spectrophotometric method. 5ml of the sample is made to react with 0.5ml ascorbic acid and 0.5ml mixed reagent (a mixture of ammonium molybdate, potassium antimony tartrate and sulphuric acid) which will give the sample a blue colour and the absorbance of this colour is measured using a spectrophotometer at a wavelength of 880 n.m (Grasshoff *et al*,1983).

(A)

(B)

Plate 1. Photographs showing the experimental set up A, B- Different Views

3.2.2 Estimation of total phosphorus

Total phosphorus is the sum of inorganic phosphorus and organic phosphorus. To estimate total phosphorus, the sample was oxidised with perchloric acid to liberate organic phosphorus as inorganic phosphate. The total phosphorus was determined by following the standard spectrophotometric method as described in 3.2.1. In this 100ml of the sample was boiled to get 50 ml. 5ml of perchloric acid was added for the digestion. It was then boiled to reduce the volume to small amount. This sample was transferred quantitatively to a crucible and heated to almost dryness. When fumes were disappeared, two or three drops of nitric acid was added and again boiled to dryness. The dried white residue was then dissolved in distilled water and the solution is made to 25 ml. From this 5 ml was used for the estimation of total phosphorus by following the same method as for available phosphorus.

3.2.3 Estimation of nitrite

The nitrite content of the sample was determined by following the standard spectrophotometric method as described in Grasshoff *et al.* (1983). In this 5 ml of the sample was made to react with 0.5ml sulphanilamide and 0.5ml 1-naphthyl ethylene diamine hydrochloride. The absorbance was measured using a spectrophotometer at a wavelength of 540 nm. Concentration was calculated by using calibration factor worked out by using the absorbances of standard concentrations.

3.2. 4 Estimation of nitrate

For estimation of nitrate, 25ml of the sample was mixed with 5 ml of ammonia buffer solution, and the mixture passed through the cadmium reduction column to reduce the nitrate to nitrite. First 10 ml of effluent was discarded. Next 10 ml was collected. From this 5 ml was pipetted in to a test tube and the estimation of nitrite was done as discussed in the section 3.2.3 (Grasshoff *et al*, 1983).

3.2.5 Estimation of silicate

The silicate content of the sample was estimated by spectrophotometry. 5 ml of the sample was made to react with 0.5ml of acid molybdate, 0.5ml of oxalic acid and 0.25ml of the ascorbic acid. Then the absorbance of the developed blue colour was measured at a wave length of 810 n.m (Grasshoff *et al.* 1983).

3.2.6 Estimation of total iron

5 ml of the sample was made to react with 1drop of 1N HCl, a small amount of hydroxylamine hadrochloride and 0.5 ml of 1,10-phenanthroline. Absorbance was measured at a wave length of 510 n.m. Concentration was calculated by using calibration factor worked out by using the absorbances of standard concentrations (Clesceri *et al.*, 1998).

3.2.7 Estimation of chlorophyll

The chlorophyll was determined by following the standard spectrophotometric method as described in Strickland and Parsons (1972) 500ml of the water sample was filtered through Whatman GF/C7 grade glass filter papers. The filter with plankton was mascerated with a little 90% acetone in ground test tube. The extract was decanted in to a glass stoppered graduated centrifuge tube. Extraction was repeated 3 times. Volume of combined extract was adjusted to 10 ml with acetone. The solution was centrifuged for about 20 minutes under 5000 rpm. The absorbance of supernatant solution was measured using a spectrophotometer at different wave lengths, 664, 647 and 630 nm. The absorbance value was converted in to chlorophyll content using the conversion factor suggested by Scientific Committee of Oceanic Research (SCOR) as described in Strickland and Parsons (1972).

3.2.8 Estimation of pH

pH was determined using universal pH indicator solution by colour comparison. Values were periodically checked with digital pH meter .

3.2.9 Estimation of salinity

Salinity was estimated using Knudsen-Mohr titration method (Grasshoff *et al*,1983). The silver nitrate solution was prepared by dissolving 3g in 100ml for 10 ppt and 7g in 100 ml for 20 ppt. This solution was standardised against 5 ml of standard seawater, having a chlorinity of 19.376 and supplied by Institute of Oceanographic Sciences, Godalming, England and approved by IAPSO. 5 ml of sample was titrated with same silver nitrate solution. Chlorinity of sample was calculated and converted to salinity using the relation S‰ = Chlorinity x 1.80655 as given in International Oceanographic Tables.

3.2.10 Estimation of free carbon dioxide

100 ml of the water sample was pipetted and phenolphthalein indicator was added to it. Then the sample was titrated with 0.02 N standard sodium carbonate solution to get a permanent pink color. Carbon dioxide content was calculated from the volume of alkali consumed (Chattopadhyay,1998).

3.2.11 stimation of total alkalinity

100 ml of the water sample was pipetted and then methyl orange indicator was added, the solution was then titrated with 0.02N standard HCl to get a color change from golden yellow to orange red. Total alkalinity was calculated from the titre value (Chattopadhyay,1998).

3.2.12 Estimation total hardness

100 ml of the sample was pipetted. To this sample 5ml ammonia buffer was added and also a small quantity of Eriochrome black T indicator. Titration was done with 0.02 Molar standard EDTA to get a color change from wine red to blue (Chattopadhyay,1998).

3.2.13 Estimation of Calcium

100 ml of the sample was pipetted and to this 5ml of 10% NaOH was added. Small quantity of murexide indicator also was added and then titrated

with 0.02 Molar standard EDTA solution to get a colour change from wine red to violet (Chattopadhyay,1998).

3.2.14 Estimation of dissolved oxygen

Standard Winkler's method (Strickland and Parsons, 1972) was followed for the estimation of dissolved oxygen content of water samples. Water samples were collected in 125 ml clean oxygen bottles with out entrapping of air bubbles. 1 ml of Winkler-A and 1 ml of Winkler-B were added to fix the dissolved oxygen. After the precipitate got settled to 1/3 of the volume of the bottle, 2 ml of 1:1 sulphuric acid was added to dissolve the precipitate completely. From this 25 ml of the solution was pipetted in to a conical flask and titrated with 0.01N standard sodium thiosulphate with starch indicator to discharge the blue colour (Chattopadhyay,1998).

3.3 Statistical analysis

The statistical design used for the experiment was 2×4×4 Factorial Completely Randomised Design with two replications, in which two salinity levels of medium like about 10ppt and 20 ppt , four treatments like single superphosphate, rockphosphate, single superphosphate with trisodium phosphate and rock phosphate with trisodium phosphate and four concetration levels ie., 0.1, 0.2 and 0.4ppm of phosphate-P and blank are included. The data have been analyzed using Analysis of Variance technique.

Results

4.RESULTS

4.1 Changes in the available phosphorus levels

Available phosphorus is the inorganic phosphorus content of the water, which is already assimilable, by the phytoplankton. Since phosphorus is a limiting nutrient in many occasions, the content of the available phosphorus has great effect in determining the primary productivity of culture waters. The estimation of available phosphorus was done in all the tanks on 1^{st},7^{th} ,14^{th} and 30^{th} days.

4.1.1 Treatment – single super phosphate

The variation of available phosphorus under the treatment of single super phosphate at low salinity level is given in the Fig.1. For the level of 0.1 ppm of phosphate-P, the available phosphate increased on 7^{th} day and then decreased on 14^{th} day. No available phosphate was observed on 30^{th} day. For the level of 0.2 ppm of phosphate-P, he available phosphate increased on 7^{th} day. Decreased and similar values were observed on 14^{th} and 30^{th} days. For the level of 0.4 ppm of phosphate-P, the available phosphate increased on 7^{th} and decreased on 14^{th} day. On 30^{th} day the available phosphate again decreased. For blank, the available phosphate decreased on 7^{th} day and available phosphate was not observed on 14^{th} day. On 30^{th} day a low value of available phosphate was observed. The maximum value of available phosphorus obtained was 0.292 ppm, which was observed on 7^{th} day under the treatment level of 0.4 ppm of phosphate- P.

The variation of available phosphorus under the treatment of single super phosphate at high salinity level is given in the Fig.2. For the level of 0.1 ppm of phosphate-P, almost same value as that on first day was observed on 7^{th} day and on 14^{th} day the available phosphate level increased, on 30^{th} day the level decreased. For the level of 0.2 ppm of phosphate-P, the available phosphate decreased on 7^{th} day, increased on 14^{th} day and again decreased on 30^{th} day. For the level of 0.4 ppm of phosphate-P, the available phosphate decreased on

7th day increased on 14th day and again decreased on 30th day. Blank also followed the same trend. The maximum value of available phosphorus observed was 0.282 ppm, it was observed on 14th day under the treatment level of 0.4 ppm of phosphate- P.

4.1.2 Treatment – rock phosphate

The variation of available phosphate under the treatment of rock phosphate at low salinity level is given in the Fig.3. For the level of 0.1 ppm of phosphate-P, the available phosphate increased on 7th day. Decreased and similar values were observed on 14th and 30th days. For the level of 0.2 ppm of phosphate-P, the available phosphate increased on 7th day, a decreased value was observed on 14th day and no available phosphate was observed on 30th day. For the level of 0.4 ppm of phosphate-P, the available phosphate increased on 7th day and observed low values on 14th and 30th days. For blank the available phosphate slightly decreased on 7th day, a slightly increased level of available phosphate was observed on 14th day. No available phosphate was observed on 30th day. The maximum value of available phosphorus observed was 0.327 ppm, it was observed on 7th day under the treatment level of 0.4 ppm of phosphate- P.

The variation of available phosphorus under the treatment of rock phosphate at high salinity level is given in the Fig.4. For the level of 0.1 ppm of phosphate-P, the available phosphate was found to increase on 7th day and available phosphate was not present on 14th day and on 30th day a slightly increased level of available phosphate was again observed. For the level of 0.2 ppm of phosphate-P, the available phosphate level increased on 7th day, decreased on 14th day and almost same level of available phosphate was observed on 30th day. For the level of 0.4 ppm of phosphate-P also, the available phosphate level followed the same trend. For blank, the available phosphate continuously decreased on 7th and 14th days, and was not observed on 30th day. The maximum value of available phosphorus of 0.328 ppm, it was observed on 7th day under the treatment level of 0.4 ppm of phosphate- P

4.1.3 Treatment – single superphospahte + trisodium phosphate

The variation of available phosphorus under the treatment of single super phosphate with trisodium phosphate at low salinity level is given in the Fig.5. For 0.1, 0.2 and 0.4 ppm of phosphate-P, the available phosphate increased on 7th day and decreased on 14th and 30th days. For blank the available phosphate slightly decreased on 7th day and no available phosphate was observed on 14th and 30th days. The maximum value of available phosphorus observed was 0.352 ppm, it was observed on 7th day under the treatment level of 0.4 ppm of phosphate- P.

The variation of available phosphorus under the treatment of single superphosphate with trisodium phosphate at high salinity level is given in the Fig. 6. For 0.1, 0.2 and 0.4 ppm of phosphate-P, the available phosphate levels increased on 7th day, decreased on 14th day and then again slightly increased on 30th day. For blank the available phosphate continuously decreased on 7th and 14th days and no available phosphate was observed on 30th day. The maximum value of available phosphorus observed was 0.382 ppm, it was observed on 7th day under the treatment level of 0.4 ppm of phosphate- P.

4.1.4 Treatment – rock phosphate + trisodium phosphate

The variation of available phosphorus under the treatment of rock phosphate with trisodium phosphate at low salinity level is given in the Fig.7. For 0.1 ppm of phosphate–P, the available phosphate increased on 7th day and no available phosphorus was observed on 14th and 30th days. For the level of 0.2 ppm of phosphate-P, the available phosphate increased on 7th day and continuously decreased on 14th and 30th days. For the level of 0.4 ppm of phosphate-P, the available phosphate increased on 7th day and then decreased on 14th day. On 30th day no available phosphate was observed. For blank the available phosphate slightly decreased on 7th day and no available phosphate was observed on 14th and 30th days. The maximum value of available phosphorus observed was 0.381ppm, it was observed on 7th day under the treatment level of 0.4 ppm of phosphate- P.

The variation of available phosphorus under the treatment of rock phosphate with tri sodium phosphate at low salinity level is given in the Fig.8. For 0.1, 0.2 and 0.4 ppm of phosphate-P, the available phosphate increased on 7th day and decreased on 14th day, for 0.2 and 0.4ppm the available phosphate again increased slightly on 30th day, but for 0.1 ppm, the available phosphate level continued almost same as that on 14th day. For blank, the available phosphate continuously decreased on 7th and 14th days, and no available phosphate was observed on 30th day. The maximum value of available phosphorus observed was 0.392 ppm, it was observed on 14th day under the treatment level of 0.4 ppm of phosphate-P.

4.1.5 Statistical analysis

Statistical analysis using ANOVA technique showed that , the observed values of available phosphorous on 7th day was significantly affected individually by salinity, type of fertilizer and their levels. The interaction between salinity and type of fertilizer, type of fertilizer and their levels and salinity and different fertilizer levels were also found to be significant. The observed values of available phosphorous on 14th and 30th days were found additionally influenced by the combined interaction between salinity, type of fertilizer and their levels.

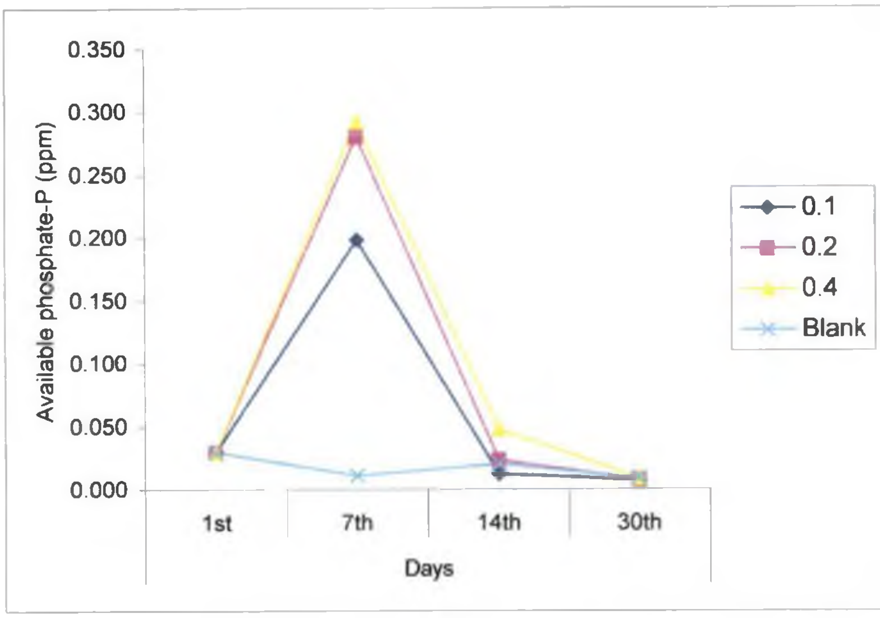

Fig.1 Variation of available phosphate under the treatment of single super phosphate at low salinity level

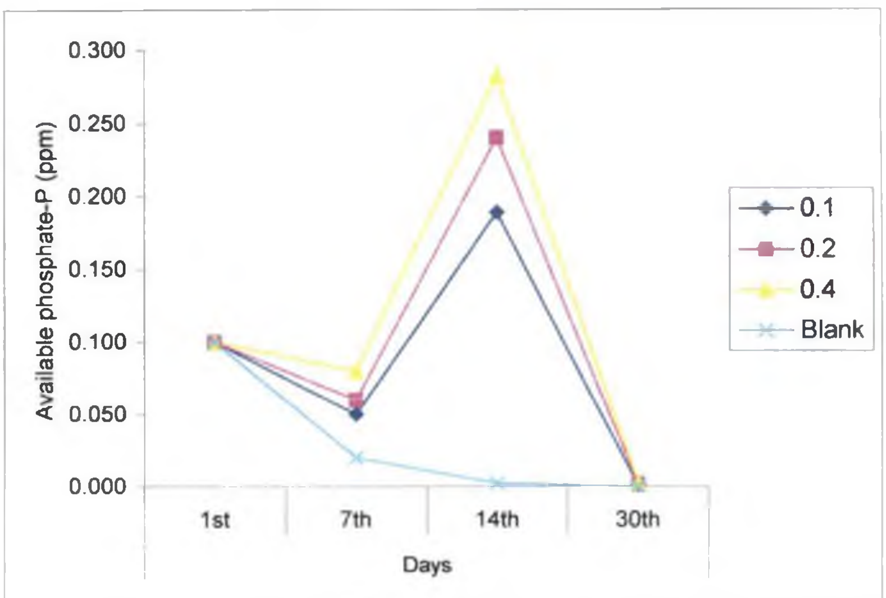

Fig.2 Variation of available phosphate under the treatment of single super phosphate at high salinity level

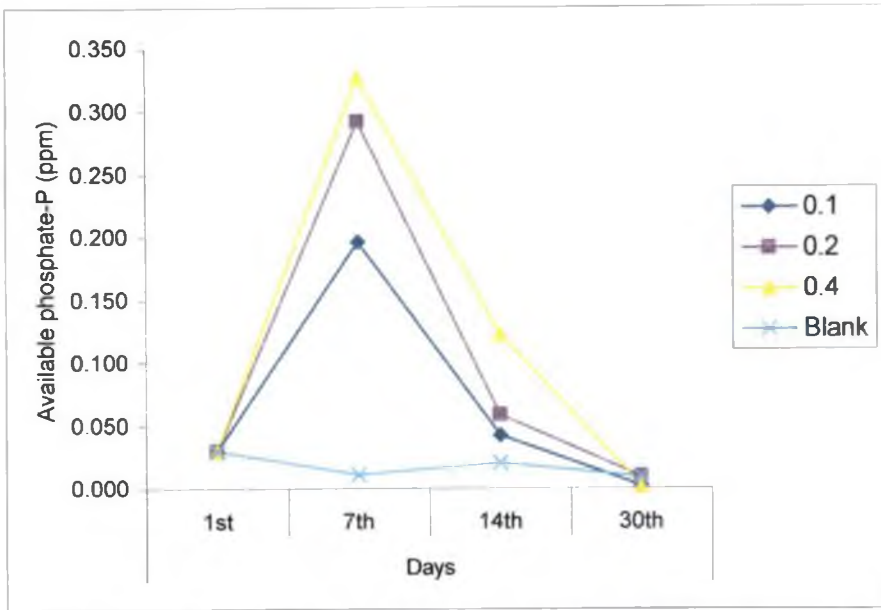

Fig.3 Variation of available phosphate under the treatment of rock phosphate at low salinity level

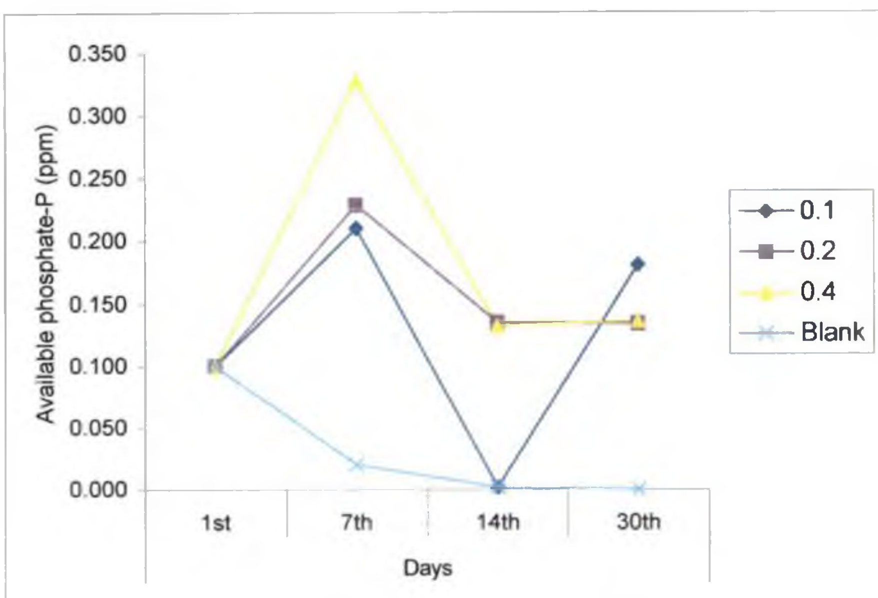

Fig.4 Variation of available phosphate under the treatment of rock phosphate at high salinity level

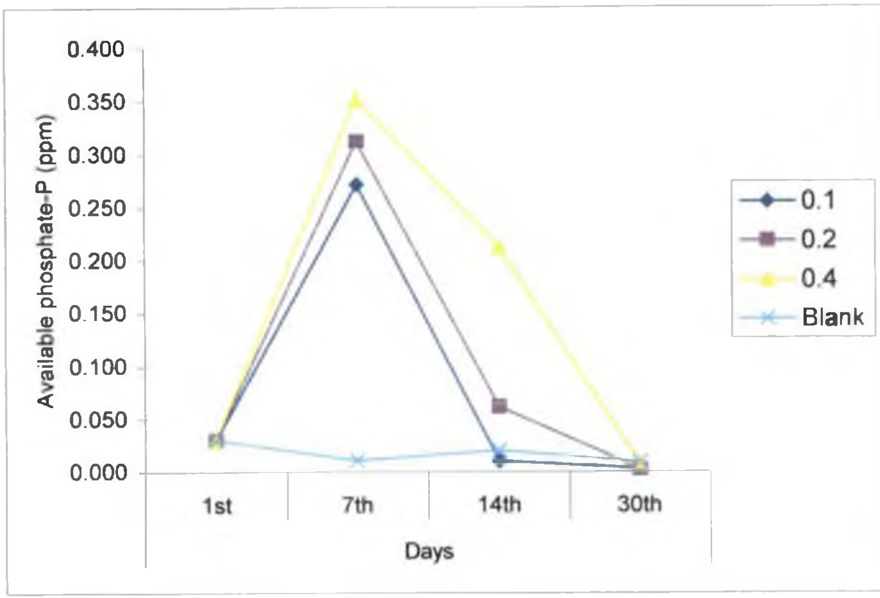

Fig.5 Variation of available phosphate under the treatment of single super phosphate + trisodium phosphate at low salinity level

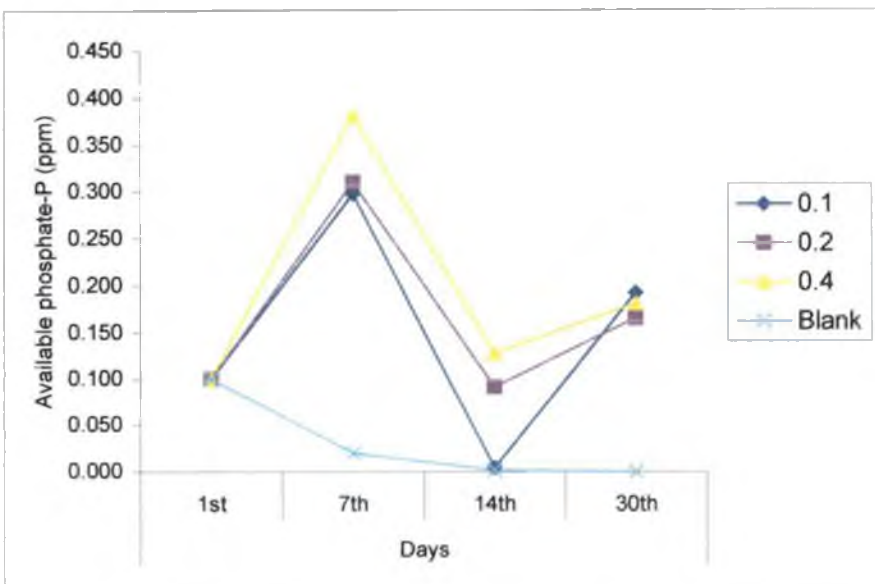

Fig.6 Variation of available phosphate under the treatment of singl super phosphate + trisodium phosphate at high salinity level

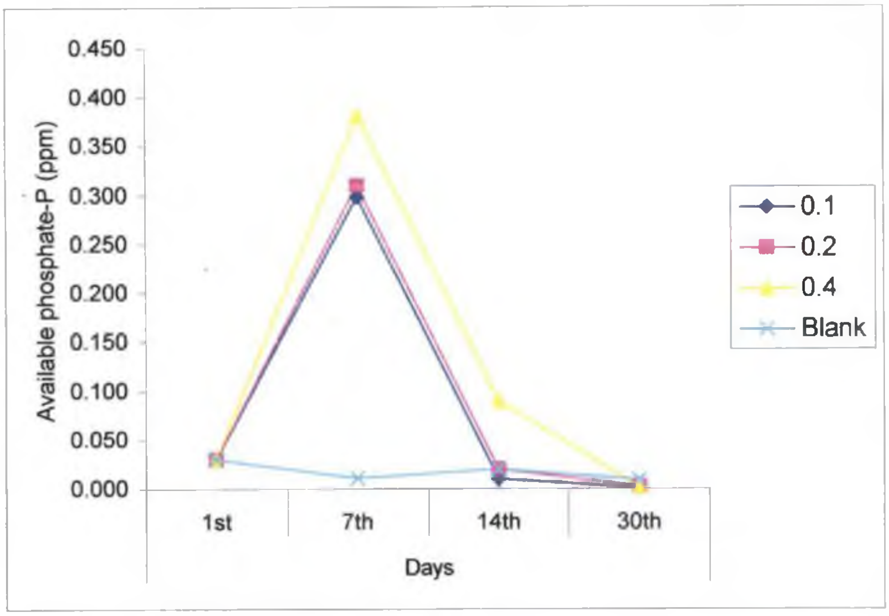

Fig.7 Variation of available phosphate under the treatment of rock phosphate + trisodium phosphate at low salinity level

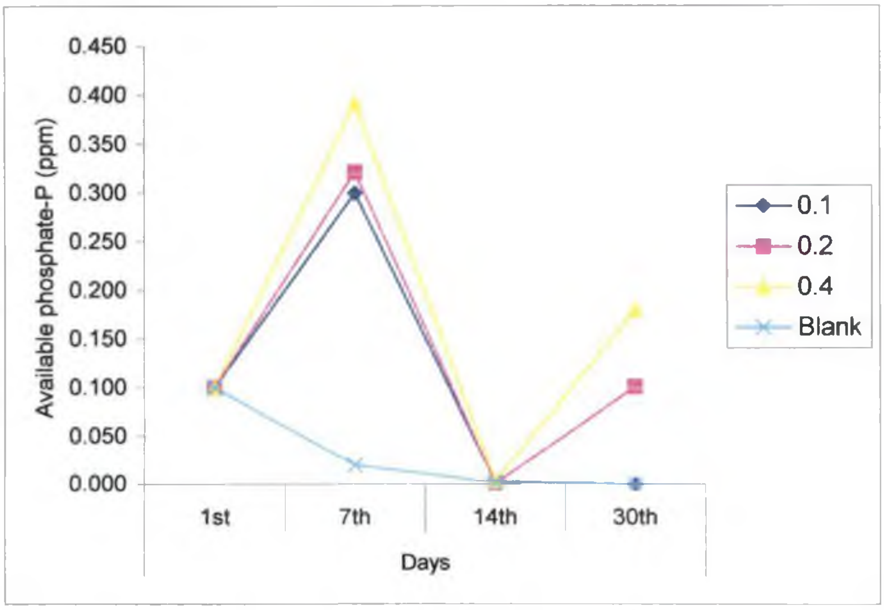

Fig.8 Variation of available phosphate under the treatment of rock phosphate + trisodium phosphate at high salinity level

4.2 Changes in the total phosphorus levels.

Total phosphorus is the sum of inorganic phosphorus (available phosphorus) and organic phosphorus content of the water. Total phosphorus was estimated to examine whether any other forms of phosphorus were present, so it was estimated on 1^{st} and 30^{th} day only.

4.2.1 Treatment- single super phosphate.

The variation of total phosphorus under the treatment of single super phosphate at low salinity level is given in the Fig.9. Under the treatment dose of 0.1, 0.4 ppm and blank, the total phosphorus values at 30^{th} day were slightly less from the values observed on the first day. But for the 0.2ppm of phosphate-P, the total phosphorus values were slightly more on 30^{th} day. The maximum value of total phosphorus observed was 1.123 ppm, on 30^{th} day under the treatment level of 0.2 ppm of phosphate- P.

The variation of total phosphorus under the treatment of single super phosphate at high salinity level is given in the Fig.10. Under the treatment doses of 0.1, 0.2 and 0.4 ppm and also for blank slightly increased values of total phosphorus was observed on 30^{th} day. The maximum value of total phosphorus of 1.586 ppm was observed, on 30^{th} day at blank.

4.2.2 Treatment – rock phosphate

The variation of total phosphorus under the treatment of rock phosphate at low salinity level is given in the Fig.11. Under the treatment doses of 0.2 and 0.4 ppm of phosphate-P, the total phosphorus values on 30^{th} day were higher than that of first day values. But for 0.1 ppm and blank the total phosphorus values on 30^{th} day was slightly less than that on first day. The maximum value of total phosphorus observed was 1.35 ppm, it was observed on 30^{th} day under the treatment dose of 0.2 ppm of phosphate-P.

The variation of total phosphorus under the treatment of rock phosphate at high salinity level is given in the Fig.12. Under the treatment doses of 0.1,0.2 and 0.4 ppm and also for blank, the total phosphorus values were found increased on 30^{th} day. The maximum value of total phosphorus was 1.59 ppm, it was observed on 30^{th} day under the treatment level of 0.2 ppm of phosphate-P.

4.2.3 Treatment – single super phosphate + trisodiumphosphate

The variation of total phosphorus under the treatment of single super phosphate with trisodium phosphate at low salinity level is given in the Fig.13. Under the treatment dose of 0.2 ppm of phosphate-P, the observed total phosphorus levels on 30^{th} day was more than of first day, for 0.1ppm the total phosphorus value was almost same as that on first day. But for 0.4 ppm of phosphate–P and also for blank, the observed values on 30^{th} day was less than that of first day. The maximum value of total phosphorus observed was 1.2 ppm , it was observed on 30^{th} day under the treatment level of 0.2ppm of phosphate- P.

The variation of total phosphorus under the treatment of single super phosphate with tri sodium phosphate at high salinity level is given in the Fig.14. Under all the treatment doses including blank, the total phosphorus values observed on 30^{th} day was more than that of first day. The maximum value of total phosphorus observed was 1.622 ppm, it was observed on 30^{th} day under the treatment dose of 0.2 ppm of phosphate-P.

4.2.4 Treatment – rock phosphate + trisodium phosphate

The variation of total phosphorus under the treatment of rock phosphate with trisodium phosphate at low salinity level is given in the Fig.15. Under the treatment doses of 0.1,0.2 ppm and blank, the total phosphorus observed on 30^{th} day was slightly less than that on first day. But for 0.4 ppm dose, the total phosphorus level was more than that on first day. The maximum value of total phosphorus observed was 1.22 ppm, it was observed on 30^{th} day under the treatment level of 0.4 ppm of phosphate- P.

The variation of total phosphorus under the treatment of rock phosphate with tri sodium phosphate at high salinity level is given in the Fig.16. For all treatment levels including blank, the total phosphorus values recorded on 30^{th} day was more than that on 1^{st} day. The maximum value of total phosphorus recorded was 1.604 ppm, it was observed on 30^{th} day for the treatment dose of 0.2 ppm of phosphate-P.

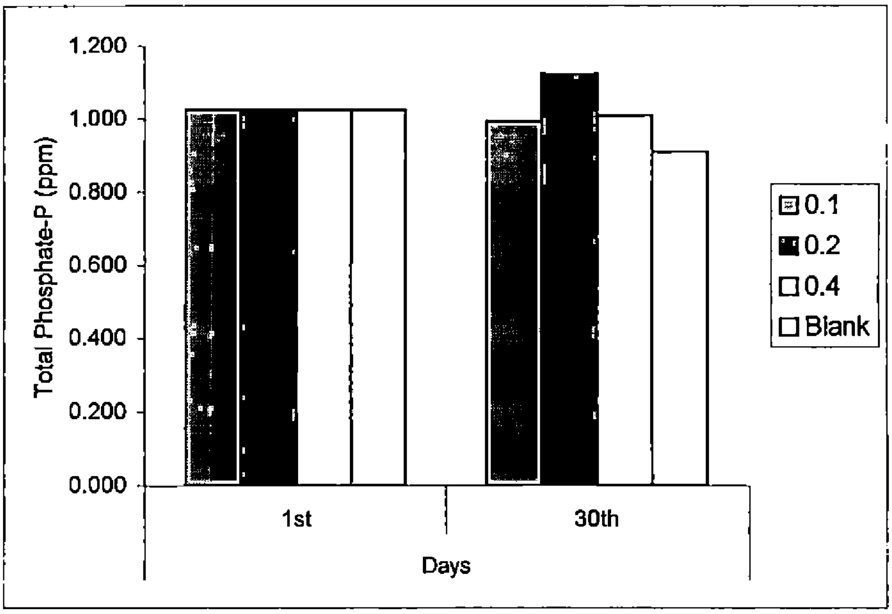

Fig.9 Variation of total phosphate under the treatment of single super phosphate at low salinity level

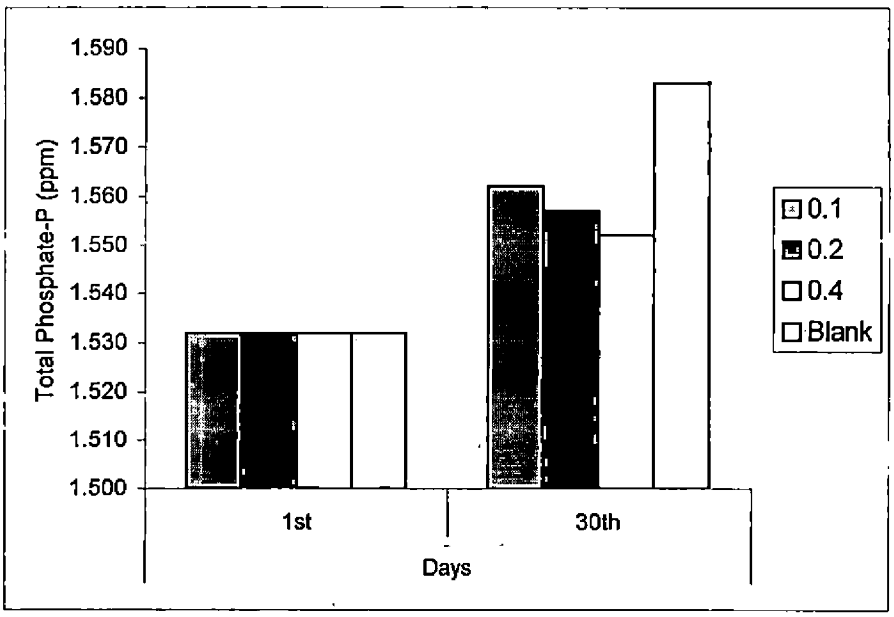

Fig.10 Variation of total phosphate under the treatment of single super phosphate at high salinity level

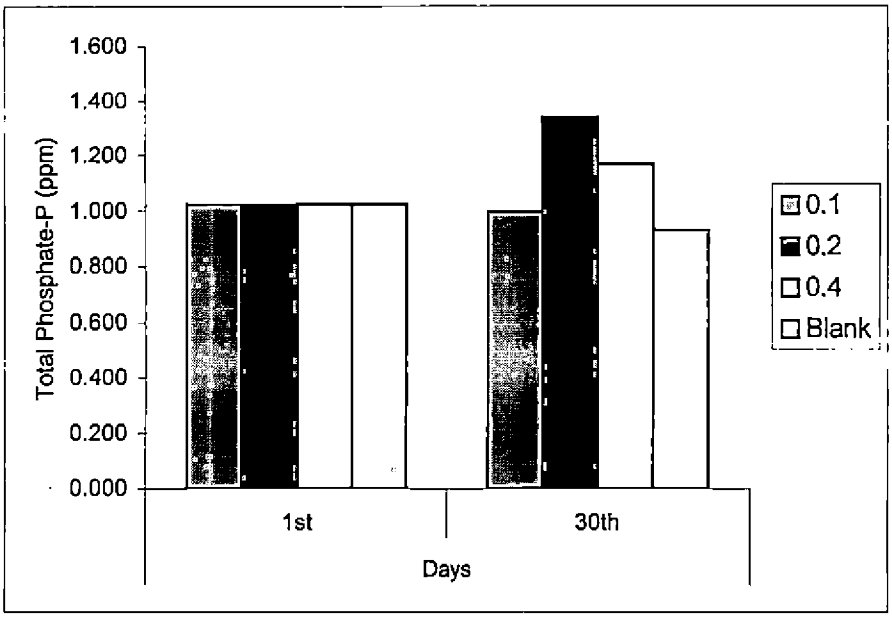

Fig.11 Variation of total phosphate under the treatment of rock phosphate at low salinity level

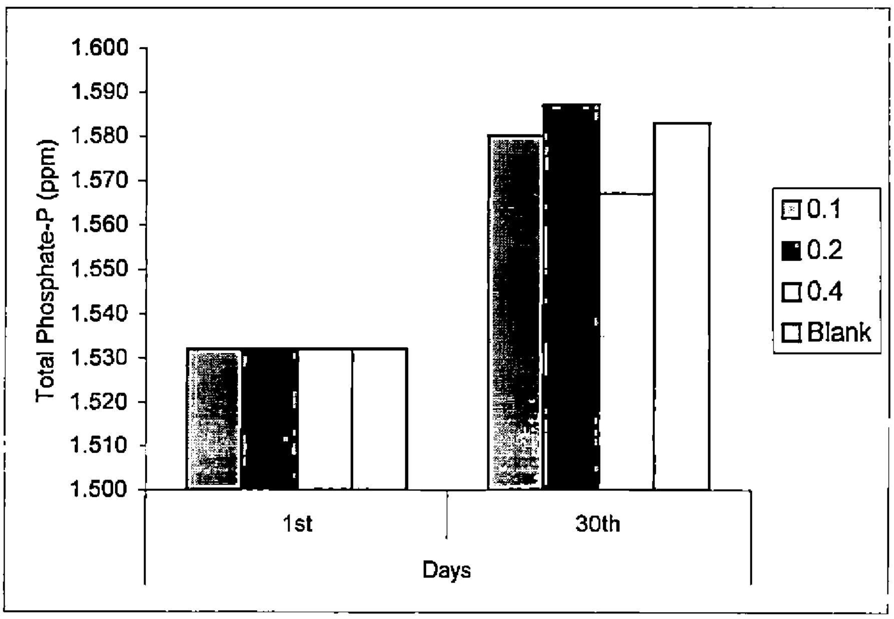

Fig.12 Variation of total phosphate under the treatment of rock phosphate at high salinity level

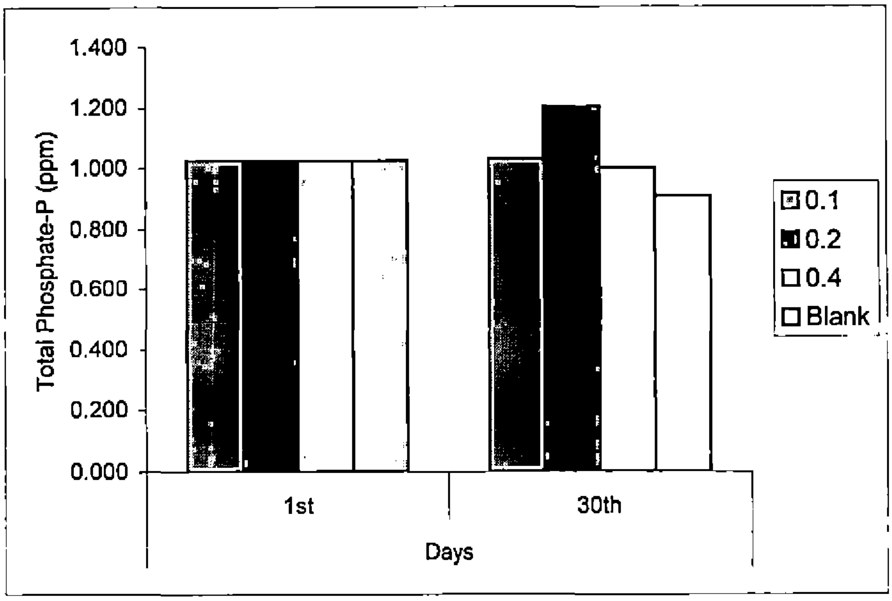

Fig.13 Variation of total phosphate under the treatment of single super phosphate + trisodium phosphate at low salinity level

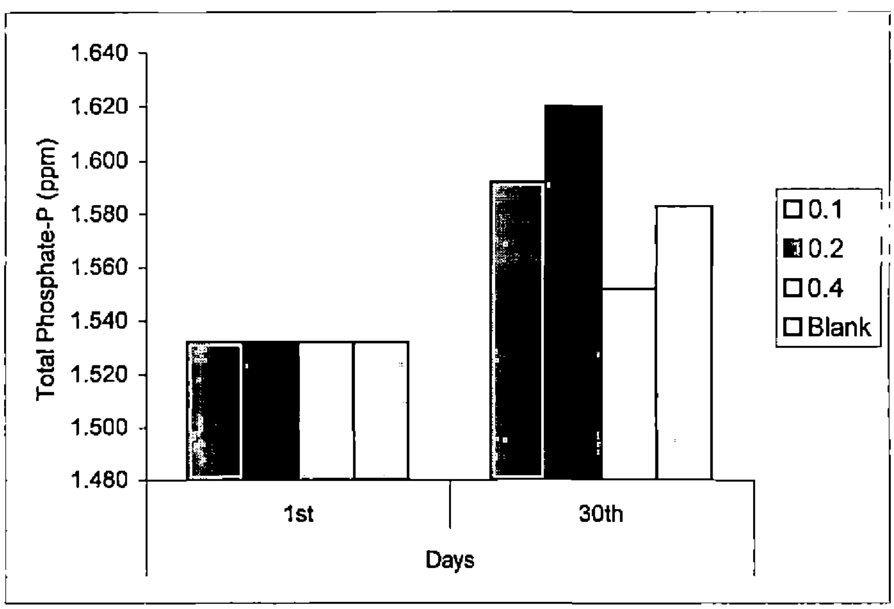

Fig.14 Variation of total phosphate under the treatment of single super phosphate + trisodium phosphate at high salinity level

4.3 Changes in the silicate levels

Silica occurs mainly as orthosilicate. Diatoms require silica for synthesis of their shells and they constitute a very prominent group in the plankton (Reddy 1997). Since silicate is a major water quality parameter as far as the primary production is concerned, its estimation was done along with the main parameters. The estimation of silicate was done in all the tanks on 1st,7th ,14th ,and 30th days.

4.3.1 Treatment – single super phosphate

The variation of silicate under the treatment of single super phosphate at low salinity level is given in the Fig.17. Under the treatment of 0.1 ppm of phosphate–P, the silicate values increased on 7th day and then decreased on 14th day and silicate was not observed on 30th day. Under the treatment of 0.2 ppm of phosphate-P, the silicate increased on 7th day and decreased on 14th and 30th days. Dose 0.4 ppm also followed the same trend. For blank the silicate values decreased on 7th day, slightly increased on 14th day, then again decreased on 30th day. The maximum value of silicate observed was 0.3 ppm it was observed on 7th day under the treatment level of 0.1 ppm of phosphate-P.

The variation of silicate under the treatment of single super phosphate at high salinity level is given in the Fig.18. For 0.2 and 0.4 ppm of phosphate –P the silicate values decreased on 7th and 14th days and then slightly increased on 30th day, the increase being more for 0.4ppm. For 0.1 ppm of phosphate –P, the values decreased on 7th day and a further decreased and similar values were observed on 14th and 30th days. But for blank, the values decreased on 7th day, slightly increased on 14th day and then again decreased on 30th day. The maximum value of silicate observed was 0.291 ppm it was observed on 14th day at blank.

4.3.2 Treatment – rock phosphate

The variation of silicate under the treatment of rock phosphate at low salinity level is given in the Fig.19. For 0.1 ppm of phosphate –P, the silicate values increased on 7^{th} day, then decreased on 14^{th} day and afterwards the values again increased. For the level of 0.2 ppm of phosphate-P level, the silicate values increased on 7^{th} day and decreased on 14^{th} day and silicate was not observed on 30^{th} day. For the level of 0.4 ppm of phosphate-P, the silicate increased on 7^{th} day and continuously decreased on 14^{th} and 30^{th} days . For blank the silicate value decreased on 7^{th} day, increased on 14^{th} day and then again decreased on 30^{th} day. The maximum value of silicate observed was 0.3 ppm it was observed on 7^{th} day under the treatment level of 0.1 ppm of phosphate- P.

The variation of silicate under the treatment of rock phosphate at high salinity level is given in the Fig.20. For 0.1 ppm of phosphate–P, decreased silicate values were observed on 7^{th} and 14^{th} days from that of first day, on 30^{th} day an increased value was observed from that of previous days. For 0.2 ppm of phosphate–P decreased values of silicate was observed on 7^{th} and 14^{th} days from that of first day, while the observed value on 30^{th} day was same as that on 14^{th} day. For 0.4 ppm of phosphate–P, decreased silicate values were observed on all the days following the first day. For blank the silicate value decreased on 7^{th} day, increased on 14^{th} day and then again decreased on 30^{th} day. The maximum value of silicate observed was 0.293 ppm, it was observed on 14^{th} day at blank.

4.3.3 Treatment- single super phosphate + trisodium phosphate.

The variation of silicate under the treatment of single super phosphate with tri sodium phosphate at low salinity level is given in the Fig.21. For 0.2 and 0.4 ppm of phosphate–P, increased silicate values were observed on 7^{th} and 14^{th} days with peaks on 14^{th} day, at 30^{th} day the silicate values decreased. For the level of 0.1 ppm of phosphate-P, the silicate value increased on 7^{th} day and then decreased on 14^{th} and 30^{th} days. For blank decreased silicate value was observed on 7^{th} day, but on 14^{th} day, the silicate value increased, on 30^{th} day the value again decreased. The maximum value of silicate observed was 0.3 ppm , it was observed on 7^{th} day under the treatment level of 0.1 ppm of phosphate- P.

The variation of silicate under the treatment of single super phosphate with tri sodium phosphate at high salinity level is given in the Fig.22. For 0.1, 0.2 and 0.4 ppm of phosphate-P, decreased silicate values were observed on 7^{th} and 14^{th} days, on 30^{th} day the values increased. For blank decreased silicate values were observed on 7^{th} day from that of first day, but on 14^{th} day the value increased, on 30^{th} day the value again decreased. The maximum value of silicate observed was 0.290 ppm , it was observed on 14^{th} day at blank.

4.3.4 Treatment – rock phosphate + tri sodium phosphate

The variation of silicate under the treatment of rock phosphate with tri sodium phosphate at low salinity level is given in the Fig.23. For 0.1ppm phosphate P, the silicate value increased on 7^{th} day from that of first day, then decreased value was observed on 14^{th} and 30^{th} days. For the level of 0.2 ppm of phosphate-P continuously increased silicate values were observed on 7^{th} and 14^{th} days and on 30^{th} day silicate was not observed. For the level of 0.4 ppm of phosphate-P silicate value increased on 7^{th} day and decreased on 14^{th} day. On 30^{th} day the value showed a sharp decrease. For blank, the silicate level decreased on 7^{th} day, increased on 14^{th} day and then again decreased on 30^{th} day. The maximum value of silicate observed was 0.295 ppm, it was observed on 14^{th} day under the treatment level of 0.4 ppm of phosphate- P.

The variation of silicate under the treatment of rock phosphate with tri sodium phosphate at high salinity level is given in the Fig.24. For 0.1ppm of phosphate-P decreased silicate value was observed on 7^{th} day, on 14^{th} and 30^{th} days no silicate was observed. For 0.2ppm of phosphate-P on 7^{th} and 14^{th} days decreased and static values of silicate was observed, but on 30^{th} day no silicate was observed. For 0.4 ppm of phosphate- P decreased silicate value was observed on 7th day but on 14th day a slightly increased value was observed, on 30th day the values again decreased. For blank, a decreased value of silicate was observed on 7th day, on 14th day there was a sharp increase in the silicate level, on 30th day the silicate level again decreased. The maximum value of silicate observed was 0.293 ppm, it was observed on 14th day at blank.

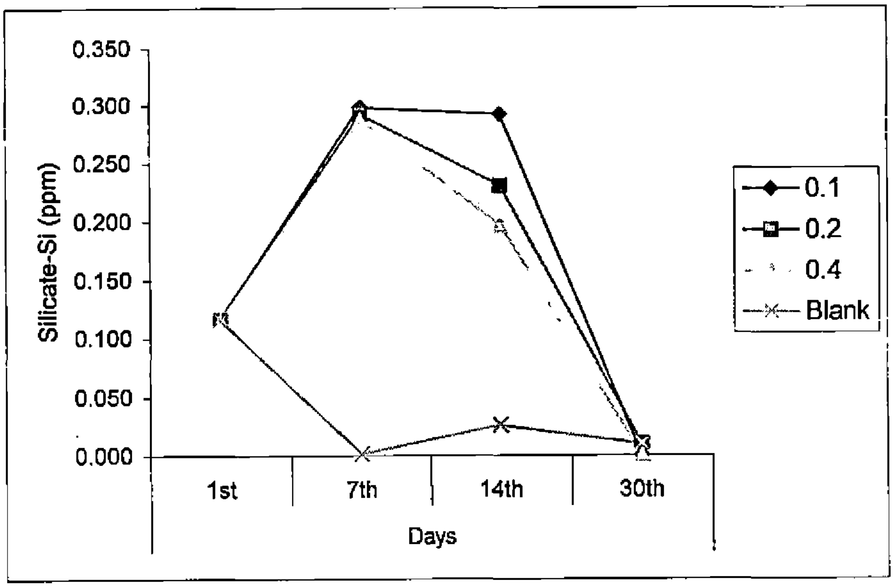

Fig.17 Variation of silicate under the treatment of single super phosphate at low salinity level

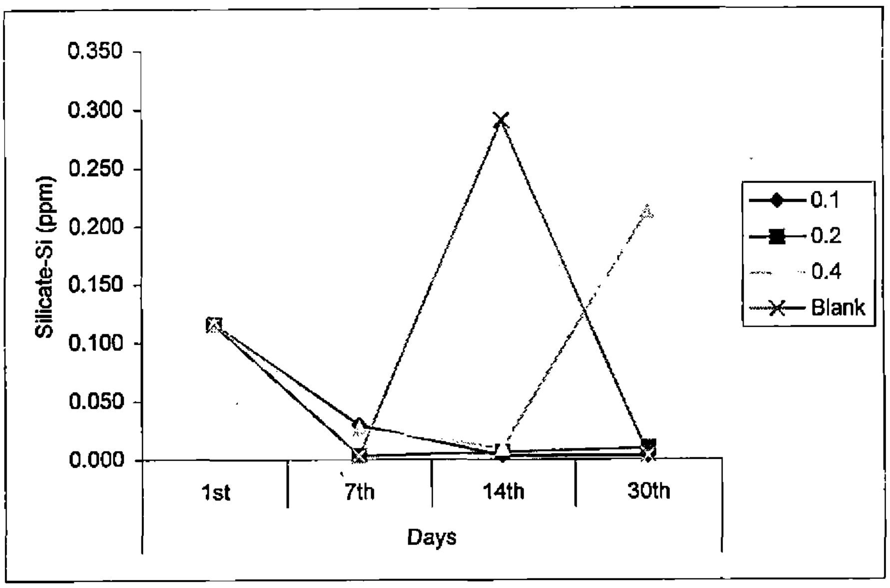

Fig.18 Variation of silicate under the treatment of single super phosphate at high salinity level

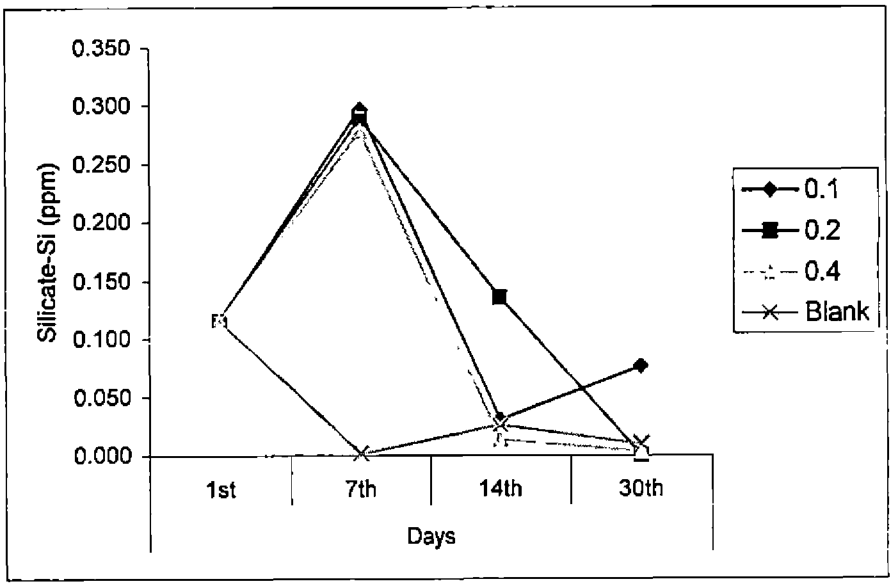

Fig.19 Variation of silicate under the treatment of rock phosphate at low salinity level

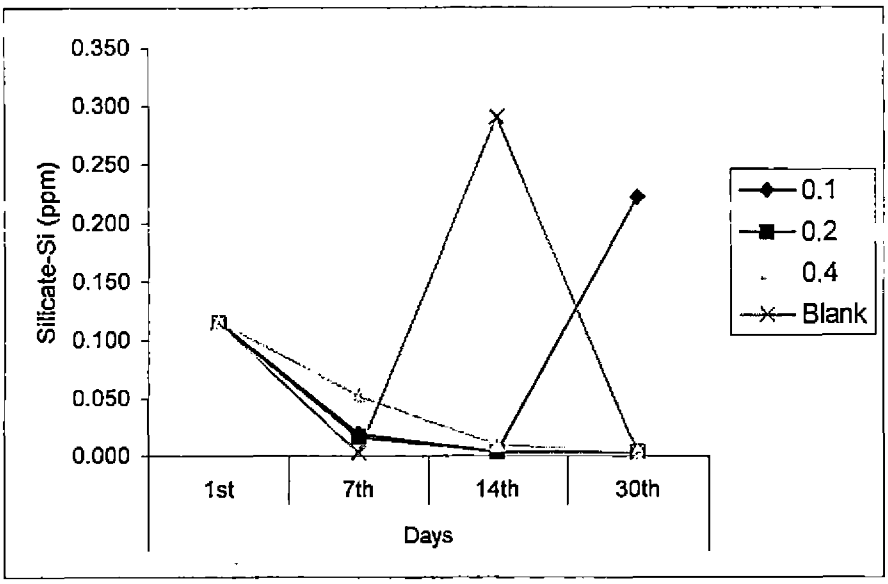

Fig.20 Variation of silicate under the treatment of rock phosphate at high salinity level

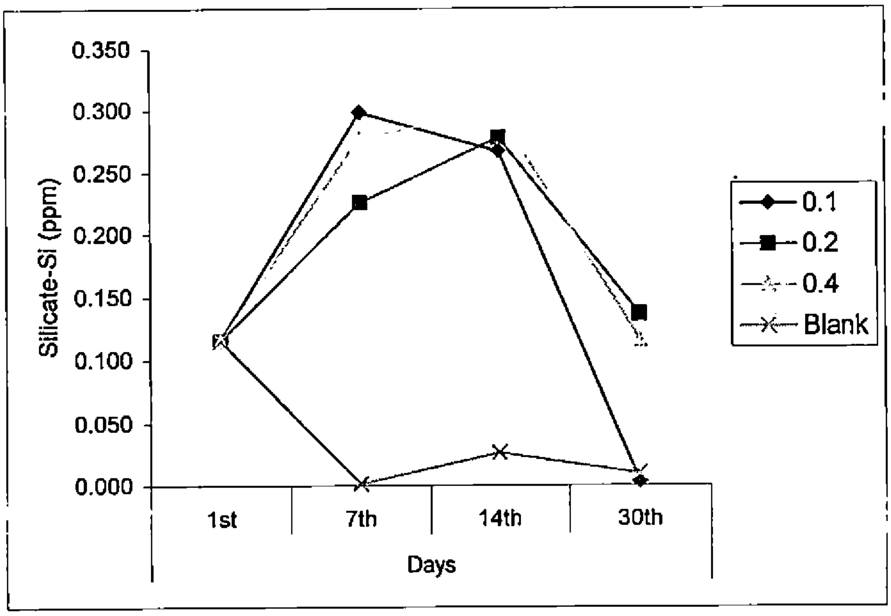

Fig.21 Variation of silicate under the treatment of single super phosphate + trisodium phosphate at low salinity level

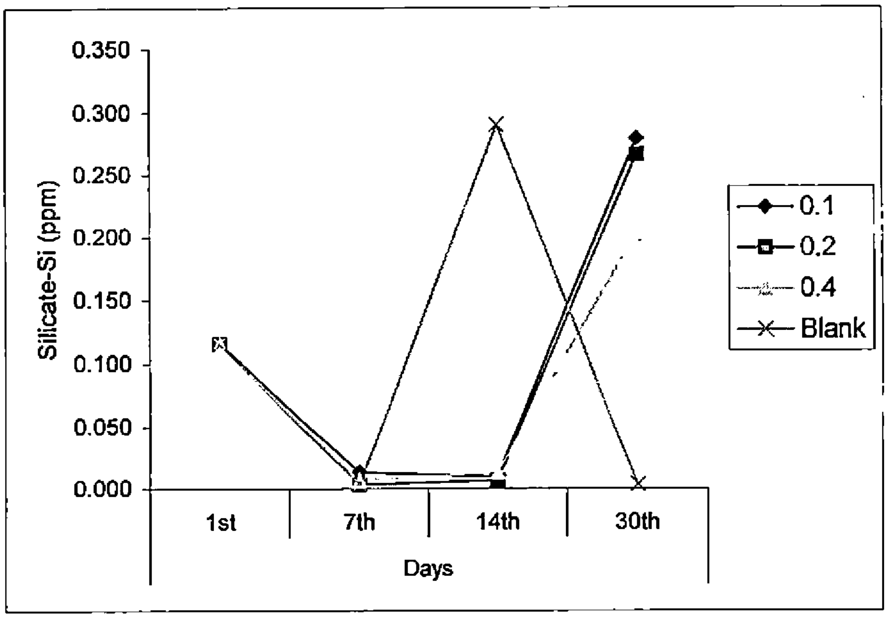

Fig.22 Variation of silicate under the treatment of single super phosphate + trisodium phosphate at high salinity level

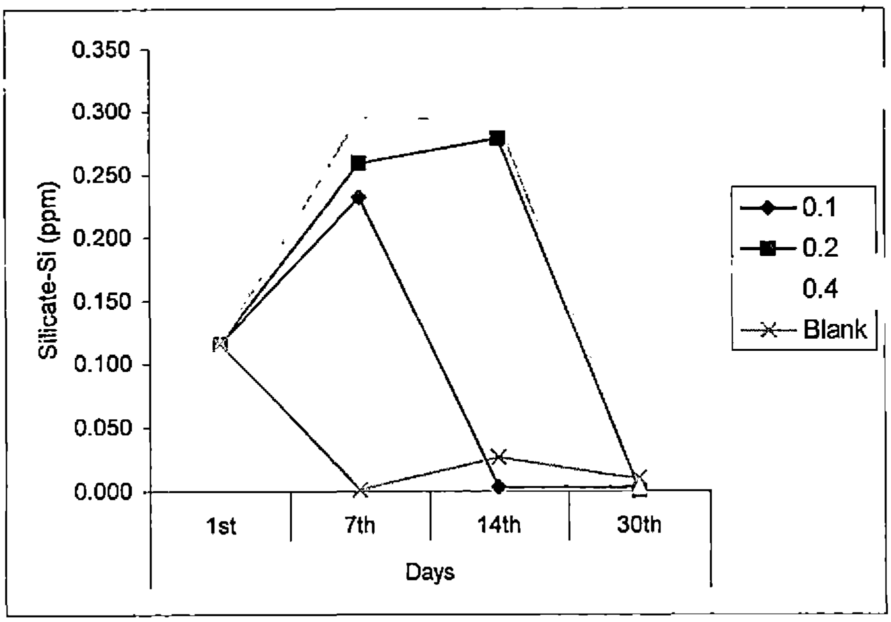

Fig.23 Variation of silicate under the treatment of rock phosphate + trisodium phosphate at low salinity level

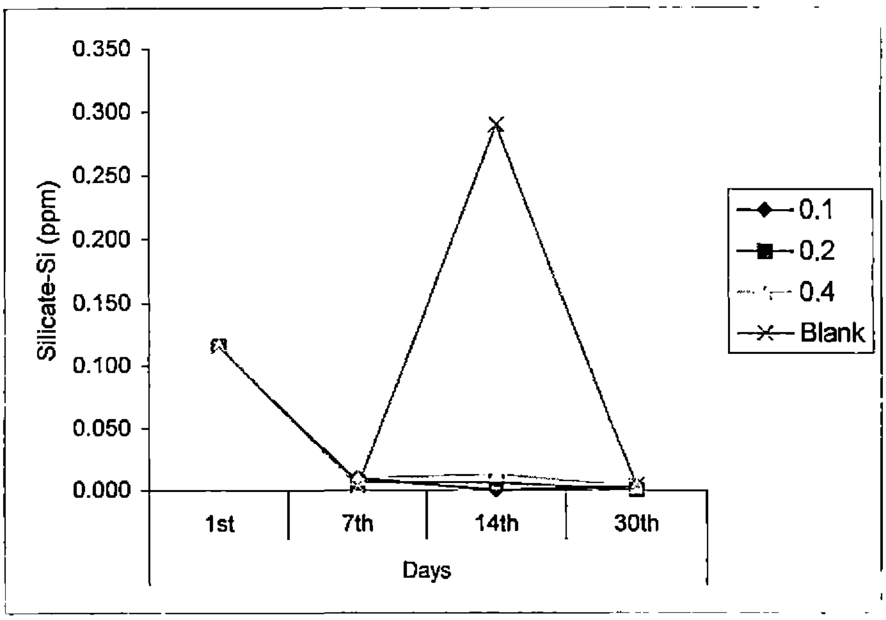

Fig.24 Variation of silicate under the treatment of rock phosphate + trisodium phosphate at high salinity level

4.4 Changes in the nitrite levels

Nitrite is the least desirable form of nitrogen in aquaculture systems, it originates from the reduction of nitrate by bacteria in the aerobic mud or water. Nitrite-N concentration in culture waters should not exceed more than 0.5mg/l , as its higher amount results in methemoglobin production (Prakash 1997). Since nitrite level is very important as far as the aquatic life is concerned , its estimation was done along with the main parameters. The estimation of nitrite was done in all the tanks on 1^{st},7^{th} ,14^{th} ,and 30^{th} days.

4.4.1 Treatment- single super phosphate

The variation of nitrite under the treatment of single super phosphate at low salinity level is given in the Fig.25. For the treatment levels of 0.1,0.2 and 0.4 ppm of phosphate-P, low levels of nitrite were observed on 7^{th} day compared to the first day, on 14^{th} day the nitrite levels in all these treatments increased, but on 30^{th} day the nitrite levels again decreased. Blank also followed the same trend. The maximum value of nitrite observed was 0.019 ppm , it was observed on 14^{th} day under the treatment level of 0.4 ppm of phosphate- P.

The variation of nitrite under the treatment of single super phosphate at high salinity level is given the Fig.26. For 0.1ppm of phosphate-P, the nitrite values on 7^{th} day showed an increase in value compared to the first day, but on 14^{th} day the nitrite level decreased. On 30^{th} day again the nitrite value showed a reduction. Treatment dose 0.4 ppm also followed the same trend. For 0.2ppm of phosphate-P reduced value was observed on 7^{th} day, but on 14^{th} day the nitrite level showed a sharp increase. On 30^{th} day again the nitrite level decreased. For blank, the nitrite values showed a continuous reduction on 7^{th} and 14^{th} days and no nitrite was observed on 30^{th} day. The maximum value of nitrite observed was 0.007 ppm , it was observed on 14^{th} day for the dose of 0.2 ppm.

4.4.2 Treatment – rock phosphate

The variation of nitrite under the treatment of rockphosphate at low salinity level is given in the Fig.27. For 0.1ppm of phosphate-P, there was a sharp reduction in the nitrite level on 7^{th} day, 14^{th} day value was also almost same as that on 7^{th} day. On 30^{th} day no nitrite was observed. For 0.2ppm of phosphate-P, there was a sharp reduction in the nitrite level on 7^{th} day, on 14^{th} day no nitrite was observed, but on 30^{th} day the nitrite level again slightly increased. For 0.4ppm of phosphate P, nitrite increased on 7^{th} day and decreased on 14^{th} and 30^{th} days. For blank a decreased value was observed on 7^{th} day and on 14^{th} day nitrite increased, on 30^{th} day the level again decreased. The maximum value of nitrite observed was 0.0085 ppm , it was observed on 7^{th} day for the dose of 0.4 ppm.

The variation of nitrite under the treatment of rock phosphate at high salinity level is given in the Fig.28. For the treatment of 0.1ppm of phosphate P, there was a sharp reduction in the nitrite level on 7^{th} day and level slightly increased on 14^{th} day and then again decreased on 30^{th} day. For 0.2ppm of phosphate-P, nitrite value showed a decrease on the 7^{th} day, increase on 14^{th} day and on 30^{th} day the value again decreased. For 0.4ppm of phosphate-P, the nitrite level increased on 7^{th} day and continuously reduced values were observed on 14^{th} and 30^{th} days. For blank there was a reduction in the nitrite level on 7^{th} day and nitrite was very low on 14^{th} and 30^{th} days. The maximum value of nitrite observed was 0.007 ppm, it was observed on 14^{th} day at 0.2ppm dose.

4.4.3 Treatment- single superphosphate + trisodium phosphate.

The variation of nitrite under the treatment of single super phosphate with trisodium phosphate at low salinity level is given in the Fig.29. The treatment doses 0.2 pm, 0.4 ppm and blank followed almost same trend of variation. For all these the nitrite level decreased on 7^{th} day, increased on 14^{th} day and then again decreased on 30^{th} day. But the treatment dose 0.1 ppm followed a different trend, in which the nitrite level showed a sharp increase on

7th day, a sharp decrease on 14th day and then again a slight increase on 30th day. The maximum value of nitrite observed was 0.0085 ppm, it was observed on 7th day for the treatment dose of 0.1 ppm.

The variation of nitrite under the treatment of single super phosphate with trisodium phosphate at high salinity level is given in the Fig.30. For 0.1ppm of phosphate-P, reduced and almost similar values of nitrite values were observed on 7th ,: 14th and 30th days. For 0.2ppm of phosphate-P, no nitrite was observed on 7th and 30th days, a very low value of nitrite was observed on 14th day. For 0.4ppm of phosphate-P a slightly increased value was observed on 7th day from that of 1st day, on 14th and 30th days no nitrite was observed. For blank the nitrite values continuously reduced on 7th, 14th and 30th days. The maximum value of nitrite observed was 0.016 ppm , it was observed on 7th day under the treatment level of 0.4 ppm of phosphate P.

4.4.4 Treatment – rockphophate + trisodium phophate

The variation of nitrite under the treatment of rock phosphate with trisodium phosphate at low salinity level is given in the Fig.31. For 0.1ppm of phosphate- P, nitrite level increased on 7th day and decreased on 14th day and no nitrite was observed on 30th day. For 0.2ppm of phosphate-P, reduced and same values were observed on 7th and 30th days. At 14th day a slightly increased value from that of 7th and 30th day was observed. For 0.4ppm of phosphate-P, a very low value of nitrite was observed on 7th day, at 14th day a slightly increased value was observed. On 30th day no nitrite was observed. blank also followed the same trend, but for blank a very low value of nitrite was observed on 30th day. The maximum value of nitrite observed was 0.008 ppm , it was observed on 14th day for the dose of 0.4 ppm.

The variation of nitrite under the treatment of rockphosphate with trisodiumphosphate at high salinity level is given in the Fig.32. For the level of 0.1 ppm of phosphate-P, very low value was observed on 7th day, on 14th day an increased value from that of 7th day was observed, on 30th day nitrite level reduced. For 0.2 ppm of phosphate –P, the nitrite level reduced on 7th day, while on 14th day no nitrite was observed, but on 30th day a very low value of nitrite was observed. Treatment dose 0.4 ppm and blank also followed the same trend. The maximum value of nitrite observed was 0.0085 ppm , it was observed on 14th day for the dose of 0.1 ppm of phosphate-P.

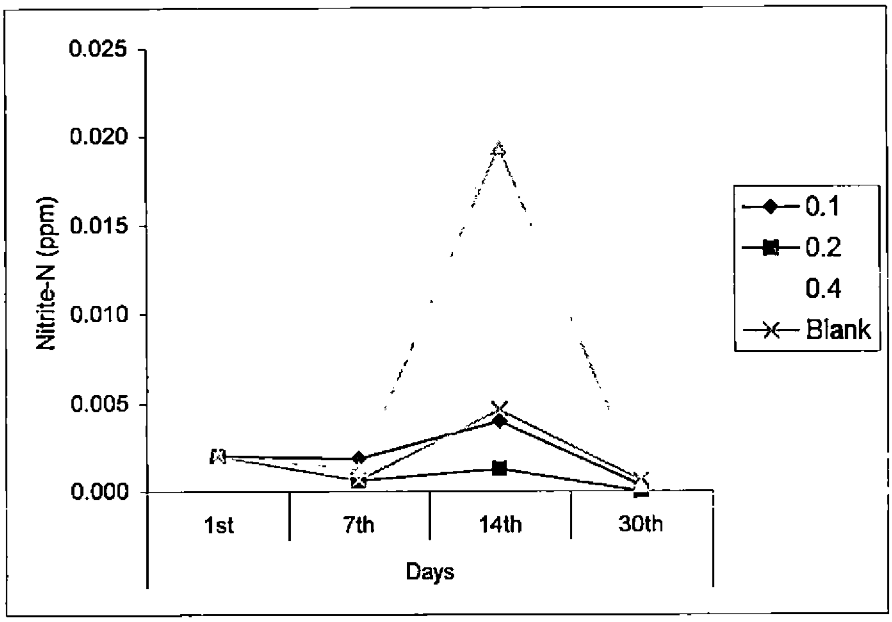

Fig.25 Variation of nitrite under the treatment of single super phosphate at low salinity level

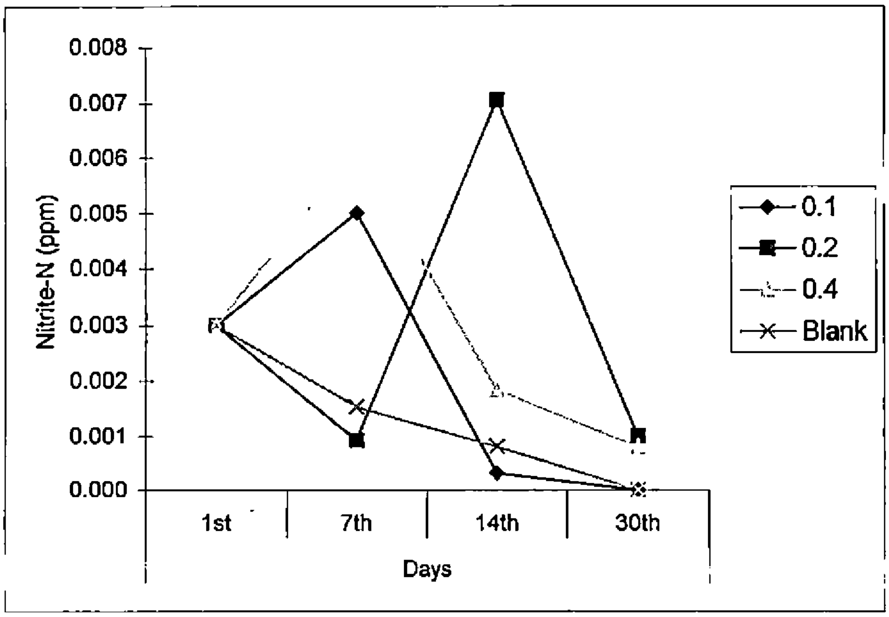

Fig.26 Variation of nitrite under the treatment of single super phosphate at high salinity level

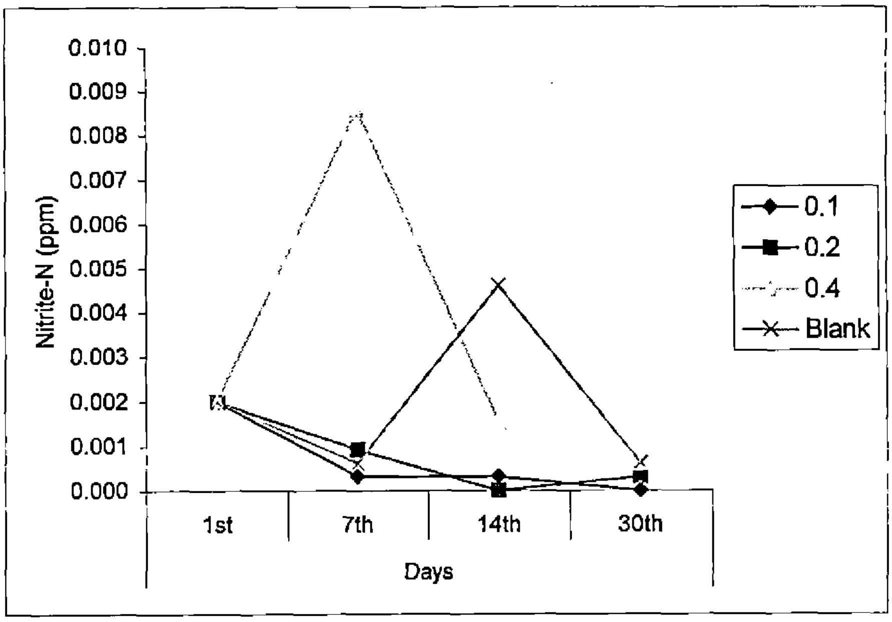

Fig.27 Variation of nitrite under the treatment of rock phosphate at low salinity level

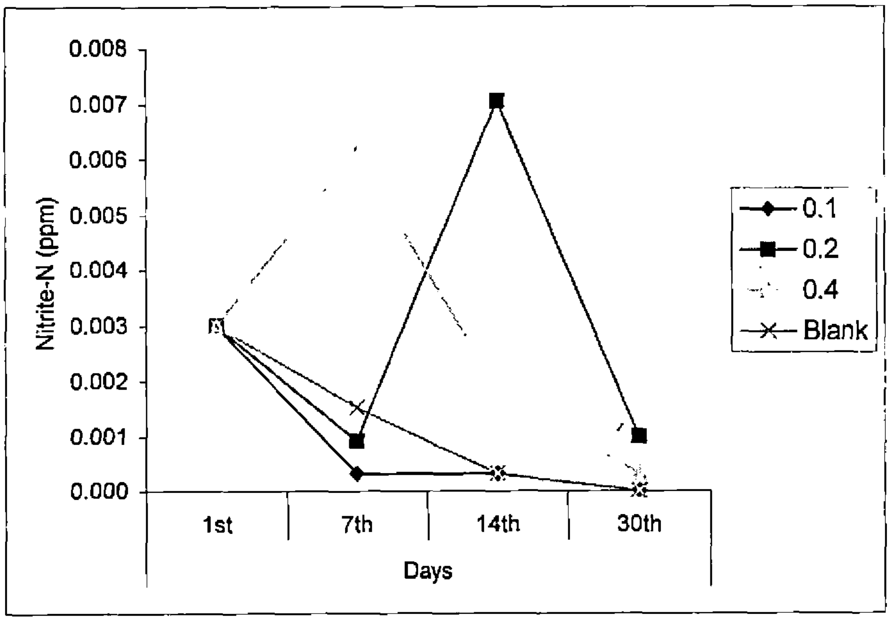

Fig.28 Variation of nitrite under the treatment of rock phosphate at high salinity level

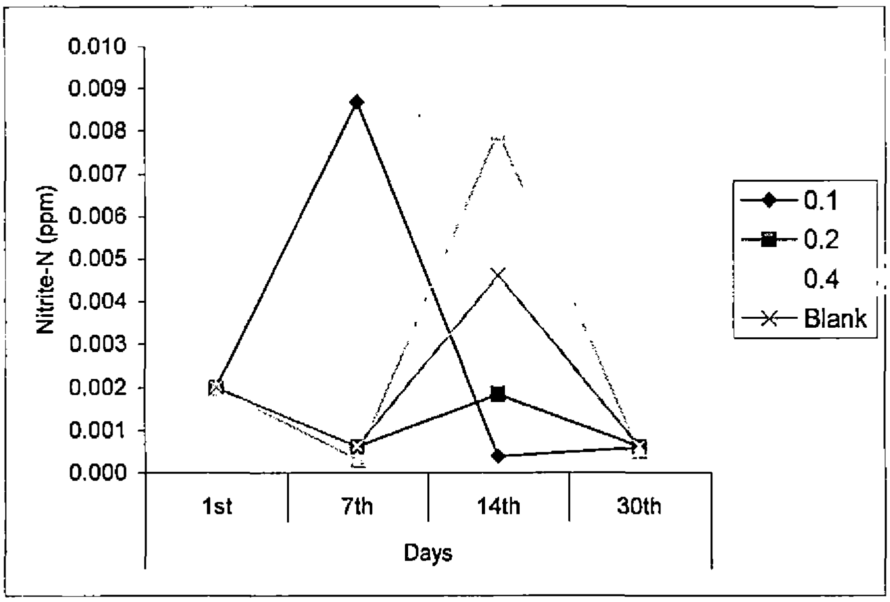

Fig.29 Variation of nitrite under the treatment of single super phosphate + trisodium phosphate at low salinity level

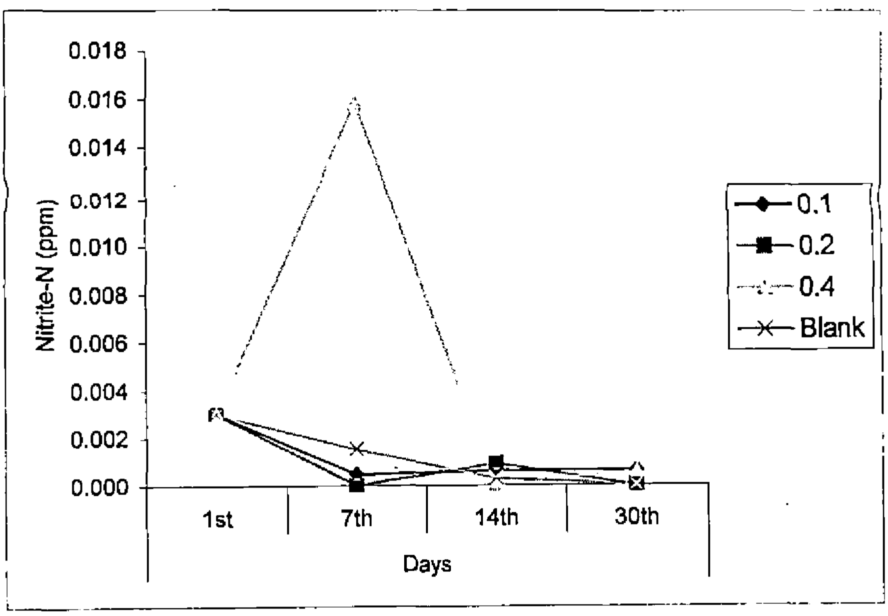

Fig.30 Variation of nitrite under the treatment of single super phosphate + trisodium phosphate at high salinity level

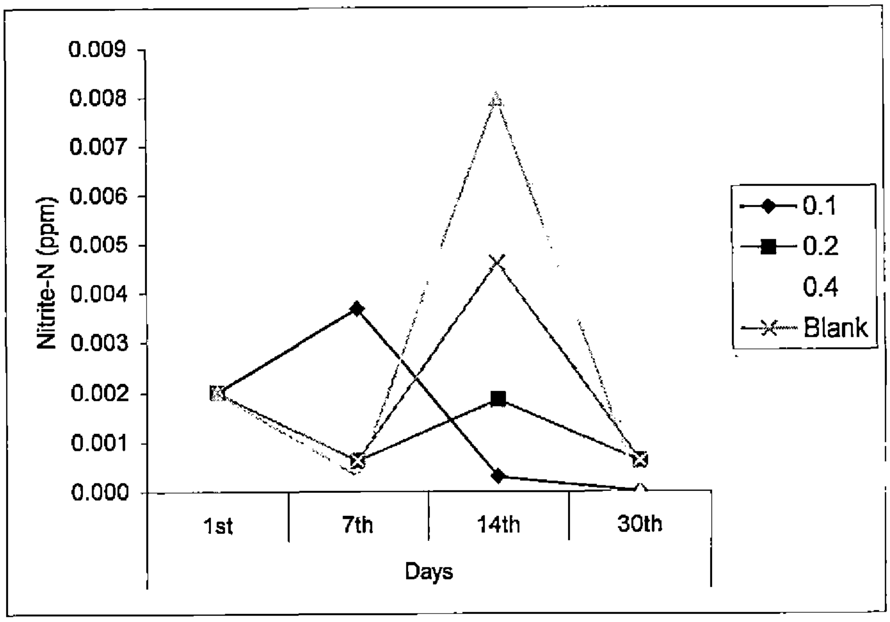

Fig.31 Variation of nitrite under the treatment of rock phosphate + trisodium phosphate at low salinity level

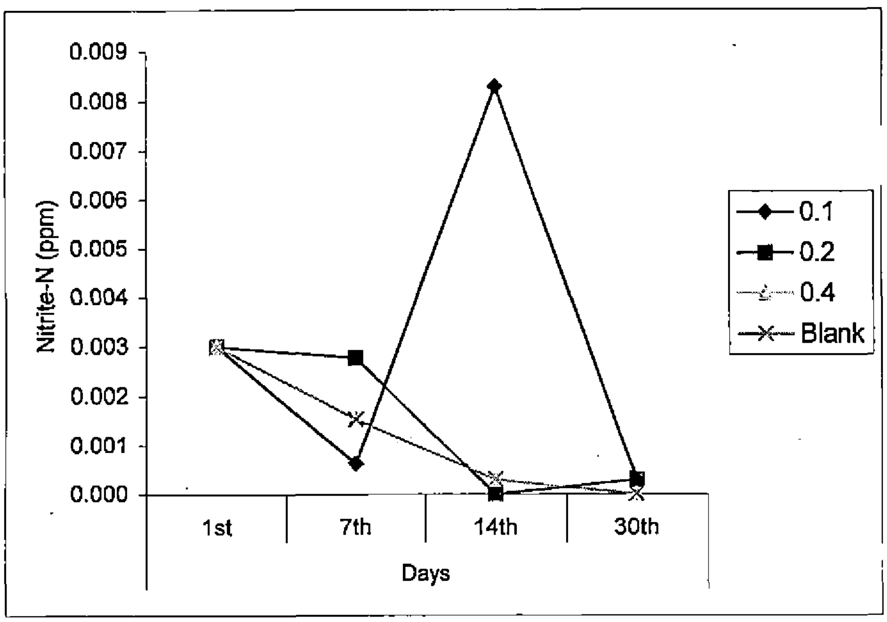

Fig.32 Variation of nitrite under the treatment of rock phosphate + trisodium phosphate at high salinity level

4.5 Changes in the nitrate levels

Nitrate (NO_3^-) is the most oxidized form of nitrogen, it is taken up in aerobic environments by algae, bacteria and plants (Valiela, 1984). Nitrate, being a major nutrient element, plays an important role in determining the fertility of culture waters. Hence determination of nitrate is an in important pre-requisite for assessing the fertility status of culture waters. In the present study the estimation of nitrate was done in all the tanks on 1st ,7th ,14th and 30th days.

4.5.1 Treatment-single superphosphate

The variation of nitrate under the treatment of single super phosphate at low salinity level is given in the Fig.33. For 0.1, 0.2 and 0.4 ppm of phosphate –P, the nitrate levels were heavily reduced on 7th day from that of first day. On 14th day the nitrate levels showed a slight increase. On 30th day the nitrate levels again reduced. For blank the nitrate levels continuously decreased over the days. The maximum value of nitrate observed was 1.535 ppm, it was observed on 1st day.

The variation of nitrate under the treatment of single super phosphate at high salinity level is given in the Fig.34. For 0.1, 0.2 and 0.4 ppm of phosphate- P, the nitrate values showed a sharp decrease on 7th day and on 14th day all these decreased values showed an increase, on 30th day all these value again reduced. For blank the nitrate values continuously decreased on 7th and 14th days, on 30th day the value showed a slight increase. The maximum value of nitrate observed was 0.434 ppm , it was observed on 1st day.

4.5.2 Treatment – rockphosphate

The variation of nitrate under the treatment of rock phosphate at high salinity level is given in the Fig.35. For 0.1, 0.2 and 0.4 ppm of phosphate –P, on 7th day the nitrate was found rapidly decreasing, on 14th and 30th days the levels slightly increased. For blank the nitrate level continuously decreased on 7th, 14th and 30th days. The maximum value of nitrate observed was 1.535 ppm , it was observed on 1st day.

The variation of nitrate under the treatment of rock phosphate at high salinity level is given in the Fig.36. For 0.1, 0.2 and 0.4 ppm of phosphate –P, the nitrate levels decreased on 7th day. On 14th day the levels slightly increased, on 30th day the levels again slightly decreased. For blank the nitrate level continuously decreased on 7th and 14th days, but on 30th day the level slightly increased. The maximum value of nitrate observed was 0.434 ppm , it was observed on 1st day.

4.5.3 Treatment – single superphosphate + trisodium phosphate

The variation of nitrate under the treatment of single superphospahte with trisodium phosphate at low salinity level is given in the Fig.37. For 0.1, 0.2 and 0.4 ppm of phosphate–P, the nitrate levels were found rapidly decreasing on 7th day, on 14th day the levels slightly increased, on 30th day the levels slightly decreased. For blank the nitrate levels continuously decreased on 7th, 14th and 30th days. The maximum value of nitrate observed was 1.535 ppm , it was observed on 1st day.

The variation of nitrate under the treatment of single super phosphate with trisodium phosphate at high salinity level is given in the Fig.38. For 0.1 and 0.4ppm of phosphate–P, the nitrate level was found suddenly decreasing on 7th day, on 14th day the level showed an increase, on 30th day the level again slightly decreased. For 0.2 ppm of phosphate–P, no nitrate was observed on 7th day, on 14th day the nitrite level showed an increase, on 30th day the nitrite level again reduced. For blank the nitrate level continuously decreased on 7th and 14th days, but on 30th day the level showed a slight increase. The maximum value of nitrate observed was 0.434 ppm , it was observed on 1st day.

4.5.4 Treatment – rock phosphate + trisodiumphosphate.

The variation of nitrate under the treatment of rockphosphate with trisodium phosphate at low salinity level is given in the Fig.39. For 0.1, 0.2 and 0.4 ppm of phosphate-P, the nitrate showed a heavy decrease on 7th day.

On 14th day the levels were slightly increased, on 30th day all the levels slightly decreased again . For blank the nitrate level continuously decreased on 7th ,14th and 30th days, with a heavy decrease on 14th day. The maximum value of nitrate observed was 1.535 ppm , it was observed on 1st day.

The variation of nitrate under the treatment of rockphosphate with trisodium phosphate at high salinity level is given in the Fig.40. For 0.1, 0.2 and 0.4 ppm of phosphate-P, the nitrate levels showed a sharp decrease on 7th day, on 14th day, the levels were increased , but on 30th day the levels again decreased. For blank the nitrate level continuously decreased on 7th and 14th days, but on 30th day the level increased. The maximum value of nitrate observed was 0.434 ppm , it was observed on 1st day.

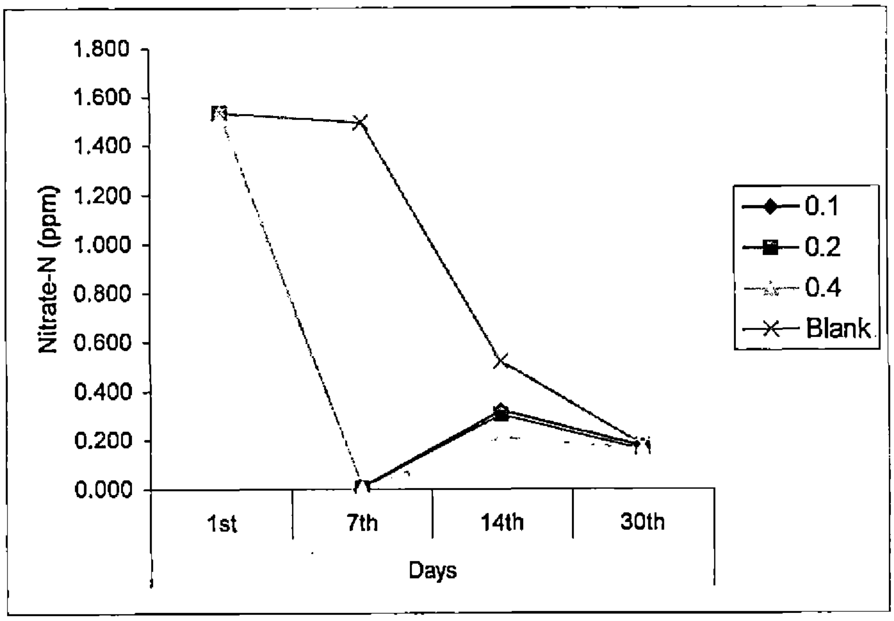

Fig.33 Variation of nitrate under the treatment of single super phosphate at low salinity level

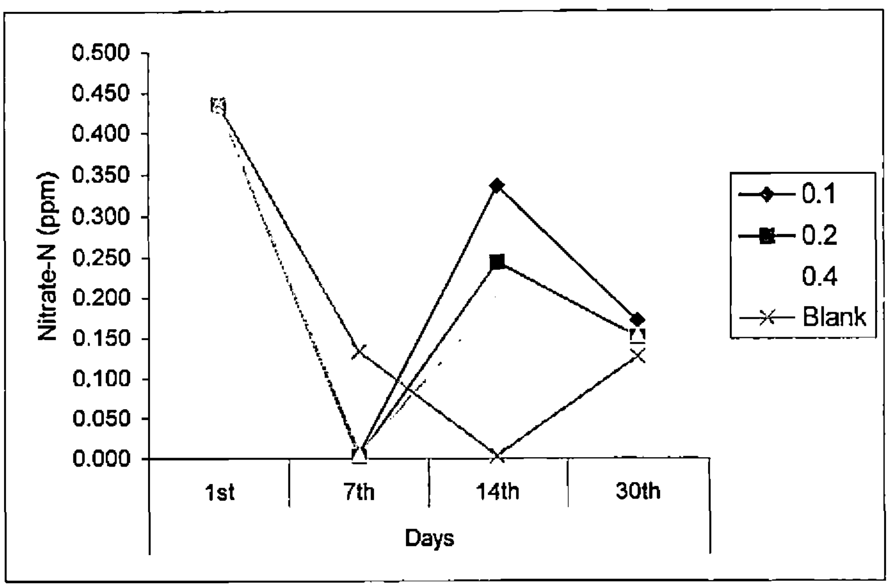

Fig.34 Variation of nitrate under the treatment of single super phosphate at high salinity level

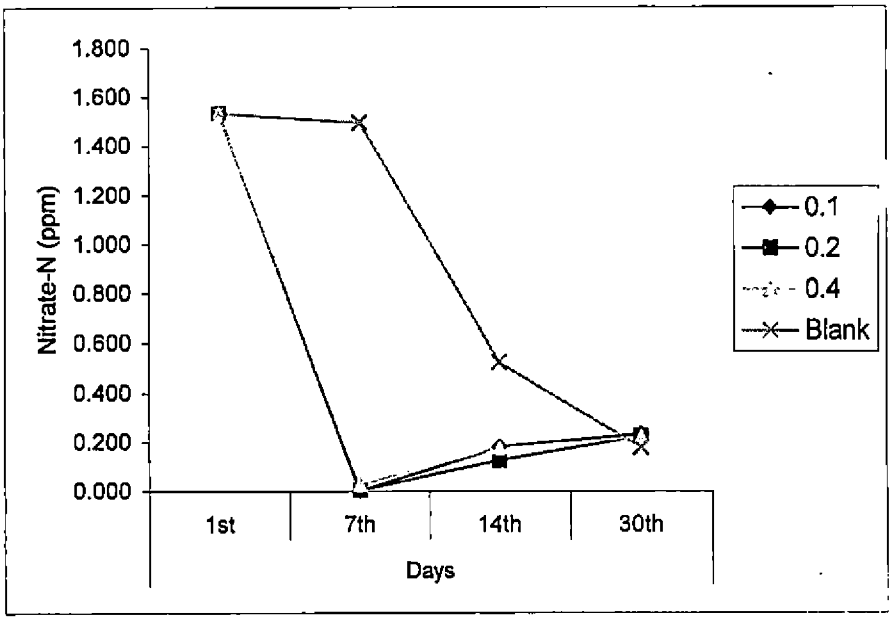

Fig.35 Variation of nitrate under the treatment of rock phosphate at low salinity level

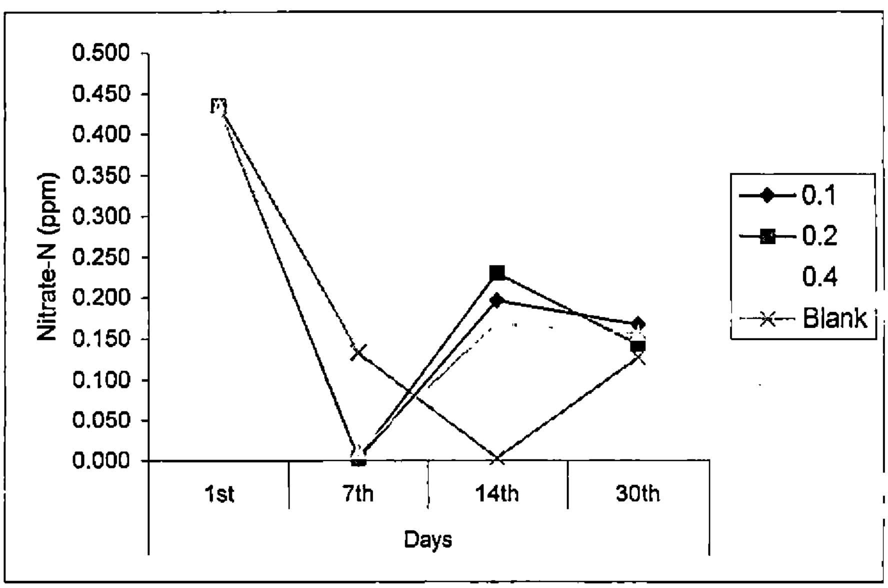

Fig.36 Variation of nitrate under the treatment of rock phosphate at high salinity level

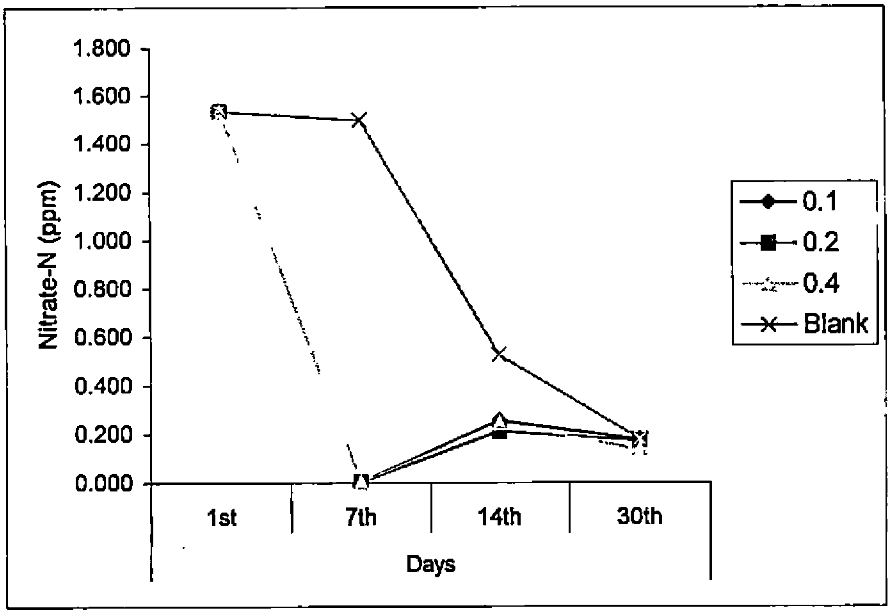

Fig.37 Variation of nitrate under the treatment of single super phosphate + trisodium phosphate at low salinity level

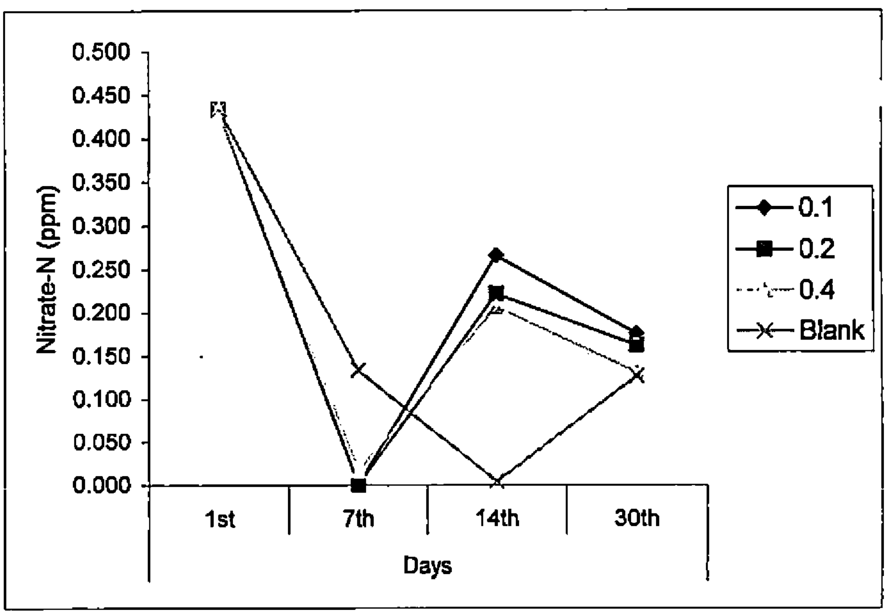

Fig.38 Variation of nitrate under the treatment of single super phosphate + trisodium phosphate at high salinity level

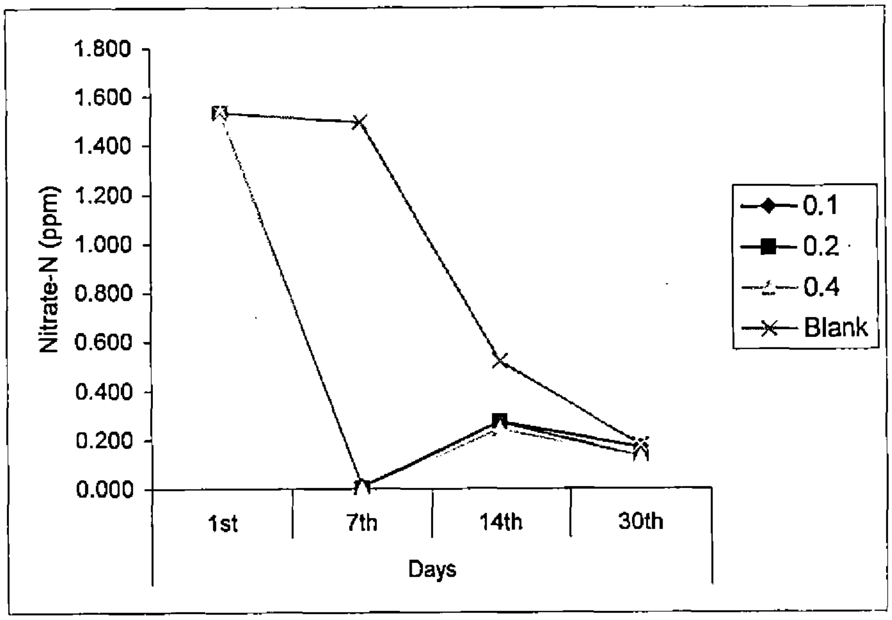

Fig.39 Variation of nitrate under the treatment of rock phosphate + trisodium phosphate at low salinity leve

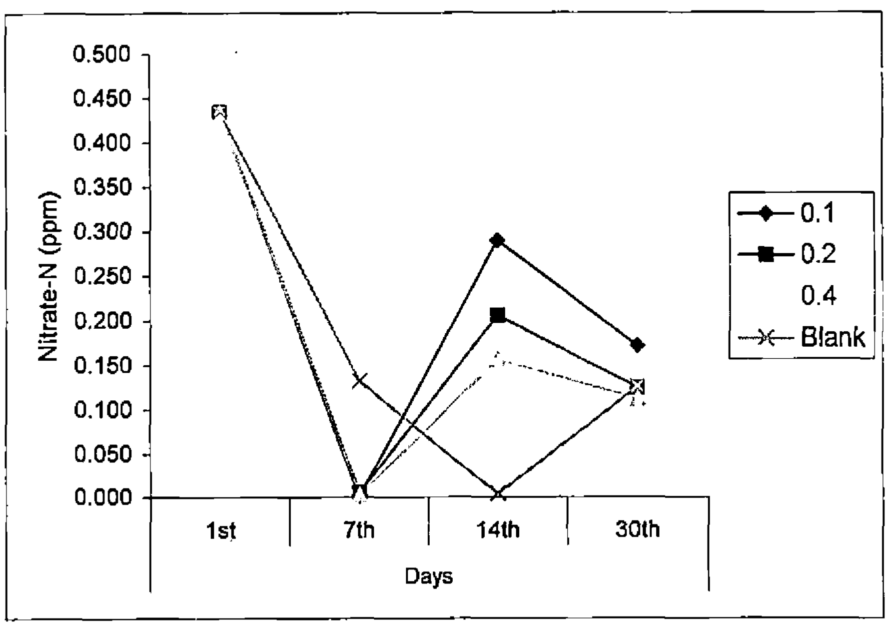

Fig.40 Variation of nitrate under the treatment of rock phosphate + trisodium phosphate at high salinity level

4.6 Changes in the iron levels

Iron can be found in many forms in culture waters, two of the most common forms are the ferrous (Fe^{2+}) and ferric(Fe^{3+})ionic states. Iron helps in the proper production of chlorophyll. Most algae grow best when the water has iron in the form of ferric oxide (Reddy, 1997).In the present study ,the iron content was also estimated in all the tanks on 1st ,7th ,14th and 30th days.

4.6.1 Treatment – single superphosphate

The variation of iron under the treatment of single super phosphate at low salinity level is given in the Fig.41. For 0.1, 0.2 and 0.4 ppm of phosphate – P , the iron levels decreased on 7th day, increased slightly on 14th day (compared to the 7th day readings) and no iron was observed on 30th day. For blank the iron level decreased on 7th day, increased on 14th day and then again decreased on 30th day. The maximum value of iron observed was 0.115 ppm, it was observed on 1st day.

The variation of iron under the treatment of single super phosphate at high salinity level is given in the Fig.42. For 0.1 ppm of phosphate–P, the iron level decreased on 7th day, then slightly increased on 14th day and then again decreased on 30th day. For 0.2 ppm of phosphate–P, the iron level decreased on 7th day, no iron was observed on 14th day and the level again increased slightly on 30th day. For 0.4 ppm of phosphate–P, no iron as observed on 7th and 14th days and the level again increased slightly on 30th day. For blank the iron level decreased on 7th day, increased on 14th day and again decreased on 30th day. The maximum value of iron observed was 0.115 ppm, it was observed on 1st day.

4.6.2 Treatment – rockphosphate

The variation of iron under the treatment of rockphosphate at low salinity level is given in the Fig.43. For the level of 0.1 ppm of phosphate-P, the iron level decreased on 7th day, increased on 14th day and again decreased on 30th day. For 0.2 ppm of phosphate–P, the iron level decreased on 7th day, no iron was observed on 14th day and again a slight amount was observed on 30th day.

For 0.4 ppm of phosphate–P, the iron level decreased on 7^{th} day, increased on 14^{th} day and no iron was observed on 30^{th} day. For blank the iron level decreased on 7^{th} day, increased on 14^{th} day and then again decreased on 30^{th} day. The maximum value of iron observed was 0.115 ppm, it was observed on 1^{st} day.

The variation of iron under the treatment of rock phosphate at high salinity level is given in the Fig.44. For 0.1 ppm of phosphate-P, the iron level decreased on 7^{th} day, increased on 14^{th} day and then again decreased on 30^{th} day. For the level of 0.2 ppm of phosphate-P, on 7^{th} and 30^{th} days same amount of iron was observed. On 14^{th} day no iron was observed. For 0.4 ppm of phosphate–P, the iron level continuously decreased on 7^{th} and 14^{th} days. On 30^{th} day no iron was observed. For blank and equal amount of iron was observed on 7^{th} and 30^{th} days. On 14^{th} day iron content was more than that of first day. The maximum value of iron observed was 0.115 ppm, it was observed on 1^{st} day.

4.6.3 Treatment – single Superphophate + trisodium phosphate.

The variation of iron under the treatment of single superphosphate with trisodium phosphate at low salinity level is given in the Fig.45. For 0.1, 0.2 and 0.4 ppm of phosphate-P, the iron levels decreased on 7^{th} day , increased on 14^{th} day and then again decreased on 30^{th} day. Blank, also followed the same trend. The maximum value of iron observed was 0.115 ppm, it was observed on 1^{st} day.

The variation of iron under the treatment of single superphosphate with trisodium phosphate at high salinity level is given in the Fig.46. For the level of 0.1 ppm of phosphate-P, the iron level decreased on 7^{th} day, increased on 14^{th} day and then again decreased on 30^{th} day. For the level of 0.2 ppm of phosphate-P, the iron level was continuously decreased on 7^{th}, 14^{th} and 30^{th} days . For 0.4 ppm of phosphate–P, the iron level decreased on 7^{th} day and increased on 14^{th} day and no iron was observed on 30^{th} day. For blank the iron level decreased on 7^{th} day, increased on 14^{th} day and then again decreased on

30^{th} day. The maximum value of iron observed was 0.115 ppm, it was observed on 1^{st} day.

4.6.4 Treatment- rockphosphate + trisodium phosphate.

The variation of iron under the treatment of rockphosphate with trisodium phosphate at low salinity level is given in the Fig.47. For the level of 0.1 ppm of phosphate-P, a very low and equal level of iron was observed on 7^{th} and 30^{th} days, on 14^{th} day a slightly increased level of iron was observed. Dose 0.2 ppm of phosphate-P also followed the same trend. For the level of 0.4 ppm of phosphate-P, the iron level decreased on 7^{th} day, increased on 14^{th} day then again decreased on 30^{th} day. Blank also followed the same trend. The maximum value of iron observed was 0.115 ppm, it was observed on 1^{st} day.

The variation of iron under the treatment of rockphosphate with tri sodium phosphate at high salinity level is given in the Fig.48. For the level of 0.1 ppm of phosphate-P, the iron level decreased on 7^{th} day, on 14^{th} and 30^{th} days no iron was observed. Dose 0.2 ppm of phosphate-P, also followed the same trend. For the level of 0.4 ppm of phosphate-P , a decreased and same level of iron was observed on 7^{th} and 30^{th} days, on14^{th} day an increased level of iron from that of 7^{th} day was observed. For blank the iron level decreased on 7^{th} day, increased on 14^{th} day , then again decreased on 30^{th} day. The maximum value of iron observed was 0.115 ppm, it was observed on 1^{st} day.

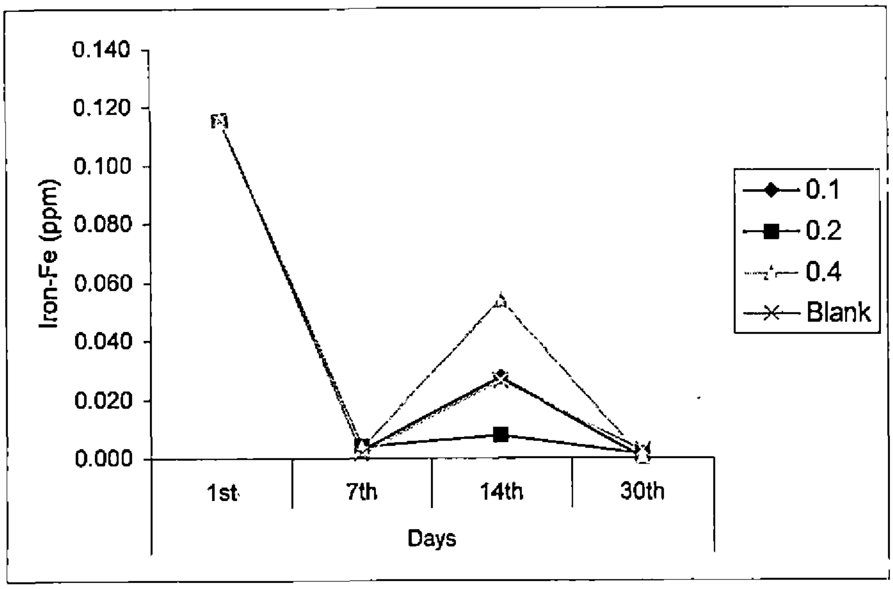

Fig.41 Variation of iron under the treatment of single super phosphate at low salinity level

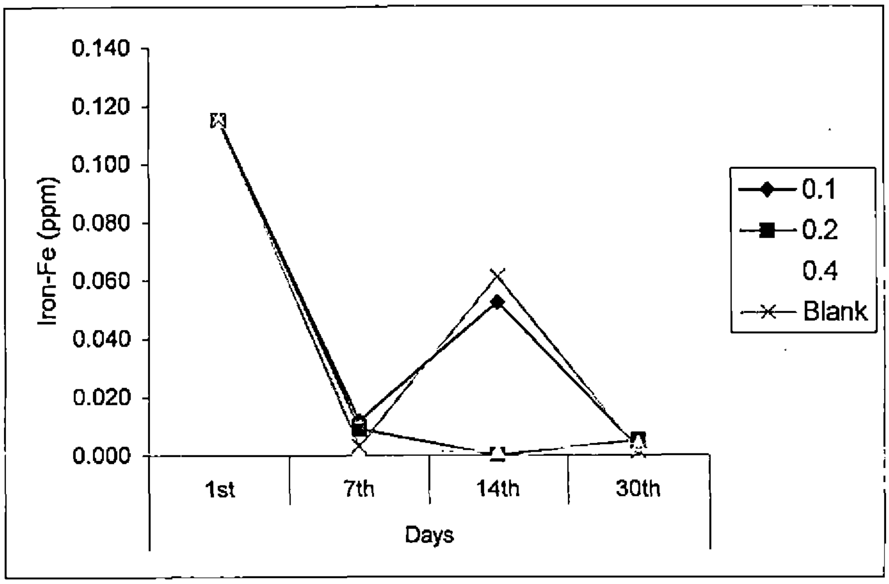

Fig.42 Variation of iron under the treatment of single super phosphate at high salinity level

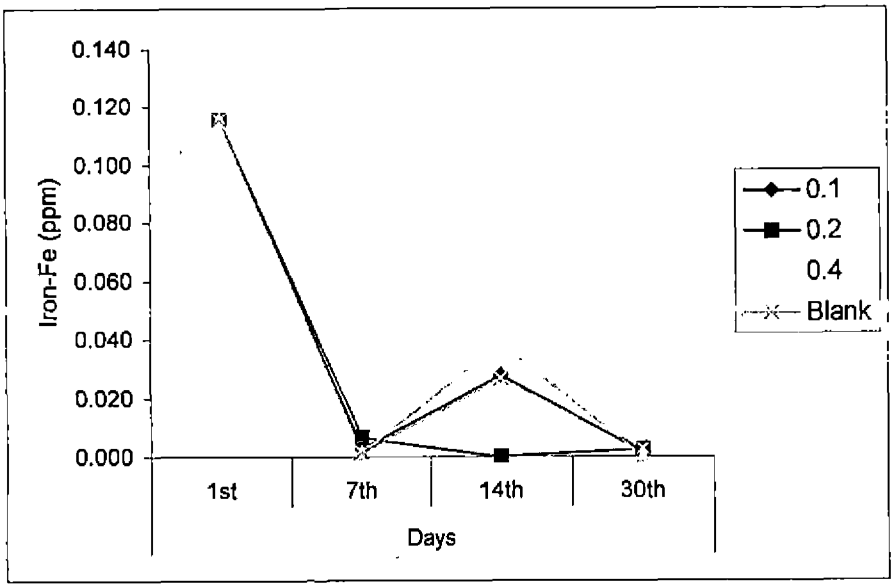

Fig.43 Variation of iron under the treatment of rock phosphate at low salinity level

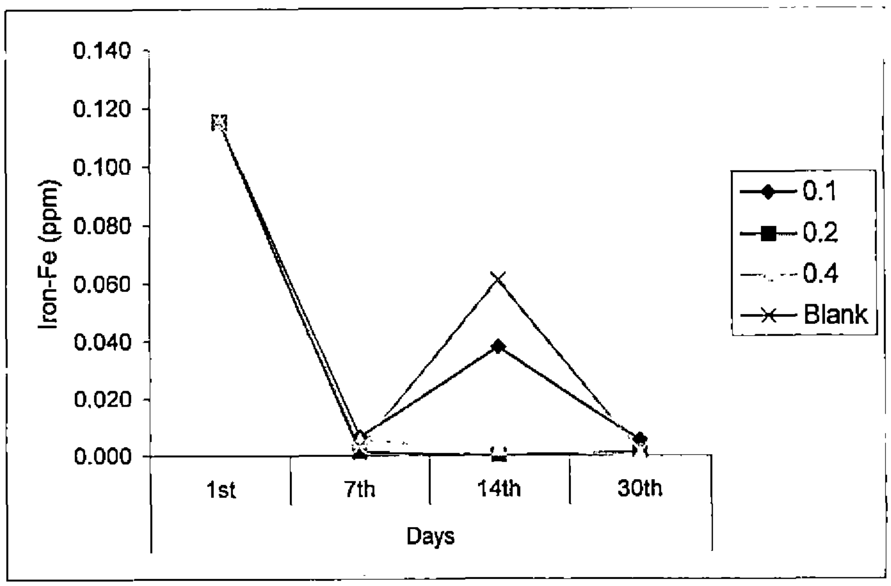

Fig.44 Variation of iron under the treatment of rock phosphate at high salinity level

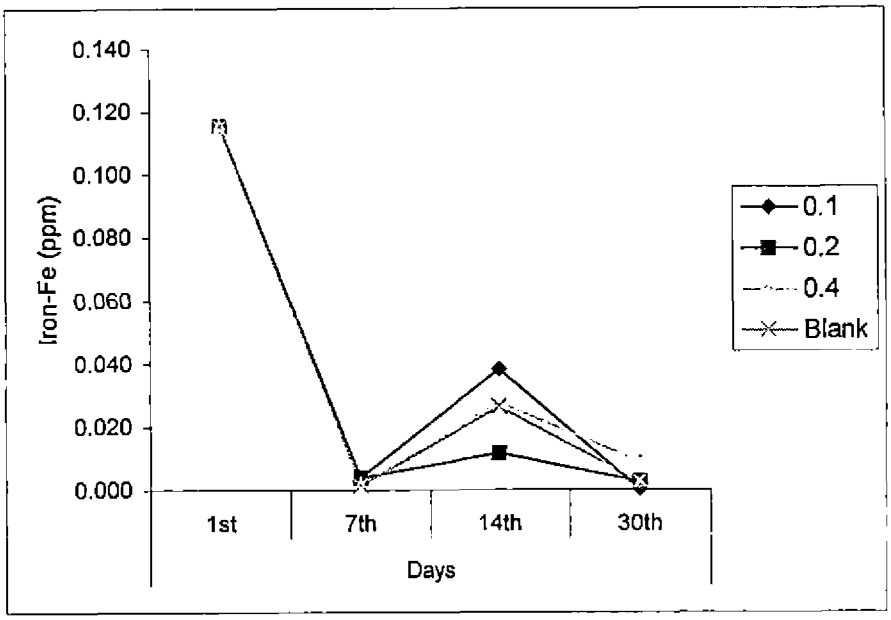

Fig.45 Variation of iron under the treatment of single super phosphate + trisodium phosphate at low salinity level

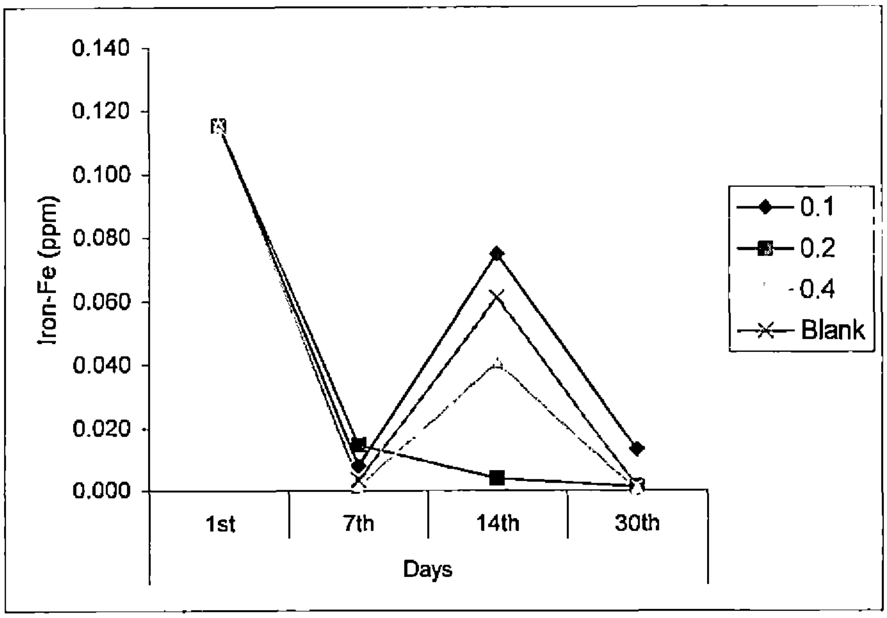

Fig.46 Variation of iron under the treatment of single super phosphate + trisodium phosphate at high salinity level

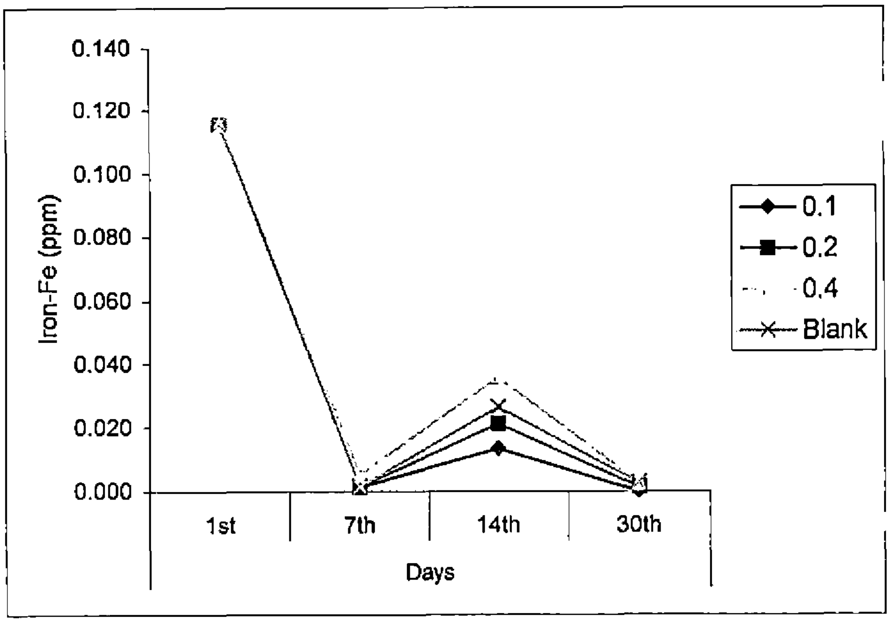

Fig.47 Variation of iron under the treatment of rock phosphate + trisodium phosphate at low salinity level

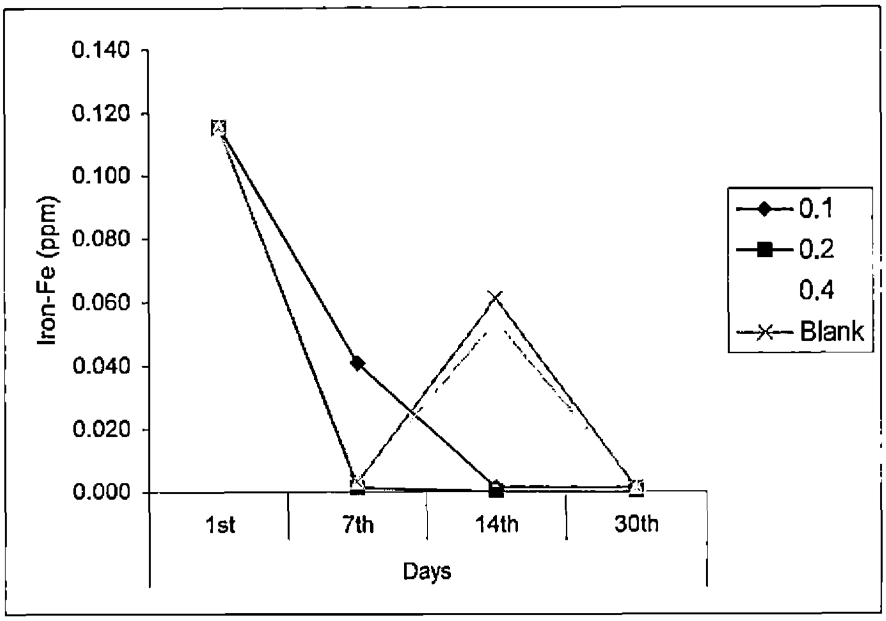

Fig.48 Variation of iron under the treatment of rock phosphate + trisodium phosphate at high salinity level

4.7 Variation of primary productivity (Chlorophyll)

Phytoplankton use chlorophylls to capture solar energy and covert it to chemical energy of adenosine triphosphate (ATP) and certain high energy reducing agents. The chemical energy so produced is then used to reduce inorganic carbon in the form of carbon dioxide to organic carbon in simple sugar (Sverdrup *et al*, 1942). Primary productivity (phytoplankton carbon) can be estimated from chlorophyll using the conversion factor 1 mg chlorophyll = 50mg carbon (Tranter, 1973). Since in the present study our main objective was to assess the changes in primary production caused by different phosphatic fertilizers, combinations and their dosages over 30 days, the primary productivity was assessed on 1^{st} and 30^{th} day only.

4.7.1 Treatment –single super phosphate

The variation of chlorophyll under the treatment of single superphospahte at low salinity level is given in the Fig.49 . The maximum chlorophyll was observed for the treatment level of 0.4ppm of phosphate–P (12.30 mg/m^3), 0.2 and 0.1 ppm of phosphate-P were in second and third position with respect to productivity. In blank lowest level of chlorophyll was observed(4.6 mg/m^3).

The variation of chlorophyll under the treatment of single superphospahte at high salinity level is given in the Fig.50. The maximum productivity was reported for the treatment level of 0.4ppm of phosphate– P (12.6 mg/m^3), 0.2 and 0.1 ppm were in second and third positions respectively. Lowest chlorophyll was observed in blank (5.8 mg/m^3).

4.7.2 Treatment – rock Phosphate

The variation of chlorophyll under the treatment of rock phosphate at low salinity level is given in the Fig.51. At 30^{th} day the maximum value of chlorophyll was observed at a treatment level of 0.4ppm of phosphate –P (12.3 mg/m^3)0.2 and 0.1ppm were in second and third positions with respect to productivity. Lowest productivity was observed for blank (4.6 mg/m^3).

The variation of chlorophyll under the treatment of rockphosphate at high salinity level is given in the Fig.52. The maximum value of chlorophyll was observed at a treatment level of 0.4ppm at phosphate- P (12.4 mg/m^3) 0.2 and 0.1ppm were in second and third positions. For blank the lowest value of productivity was observed (5.8 mg/m^3).

4.7.3 Treatment - single super phosphate + tri sodium phosphate.

The variation of chlorophyll under the treatment of single superphospahte with tri sodium phosphate at low salinity level is given in the Fig.53. Maximum level of chlorophyll was observed at a treatment level of 0.4ppm of phosphate- P (13.9 mg/m^3), 0.2 and 0.1 ppm of phosphate- P were in the second and third positions. Lowest level of chlorophyll was observed at blank(4.6 mg/m^3).

The variation of chlorophyll under the treatment of single super phosphate with tri sodium phosphate at high salinity level is given in Fig.54. Maximum productivity was reported for the treatment of 0.4ppm of phosphate- P (14.6 mg/m^3), 0.2 and 0.1 ppm were in the second and third positions respectively. At blank lowest level of chlorophyll was observed(5.8 mg/m^3).

4.7.4 Treatment - rock phosphate + tri sodium phosphate

The variation of chlorophyll under the treatment of rock phosphate with tri sodium phosphate at low salinity level is given in the Fig.55. Maximum level of chlorophyll was observed at 0.4ppm of phosphate-P (12.6 mg/m^3), 0.2 and 0.1 ppm were in the second and third positions respectively. Least level of chlorophyll was observed at blank(4.6 mg/m^3).

The variation of chlorophyll under the treatment of rock phosphate with tri sodium phosphate at high salinity level is given in the Fig.56. Maximum level of chlorophyll was observed at 0.4ppm of phosphate-P (13.6 mg/m^3), 0.2 and 0.1 ppm were in the second and third positions respectively. Lowest level of chlorophyll was observed for blank (5.8 mg/m^3).

4.7.5 Statistical analysis

The observed values of chlorophyll on 30th day was analysed statistically using the ANOVA technique (ANOVA – two factor without replication). The factors were various treatments (fertilizers) and different concentration levels. Through the analysis the F values observed were F = 7.28 at low saline medium and F = 4.21 at high saline medium. Both these values were found to be significant at 5% level. To assess weather the additive trisodiumphosphate was effective in increasing primary production, the four treatments were compared. For this purpose critical difference was calculated using the equation $CD = t_{(\text{at error df}, \alpha=0.05)} \times SE$ (Rangaswamy, 1995). The critical difference (CD) was 0.860 for low salinity and 0.690 for high salinity. The mean values observed for various treatments in low and high saline media were as follows; single superphosphate, 8.4 in low salinity and 9.65 in high salinity, rockphosphate, 8.5 in low salinity and 9.625 in high salinity, singlesuperphosphate with trisodiumphosphate, 9.925 in low salinity and 10.575 in high salinity and rockphosphate with trisodiumphosphate, 9.35 in low salinity and 9.9 in high salinity.

It was seen that in low saline medium the means with additives were significantly higher. In the high saline medium also increase was significant when trisodiumphosphate additive was used with singlesuperphosphate. In the case of rockphosphate although there was an increase in primary production, when additive was used, this was not found to be significant at 5% level. Statistical analysis also showed that, the observed values of chlorophyll on 30th day was significantly affected individually by salinity, type of fertilizer and their concentration levels. The interaction between salinity and type of fertilizer, type of fertilizer and their levels and salinity and different fertilizer concentration levels were also found to be significant.

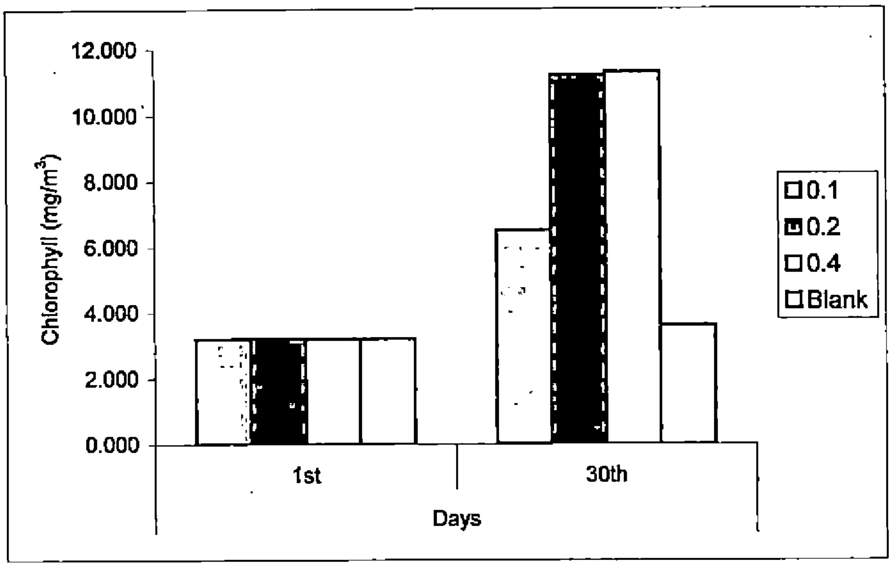

Fig.49 Variation of chlorophyll under the treatment of single super phosphate at low salinity level

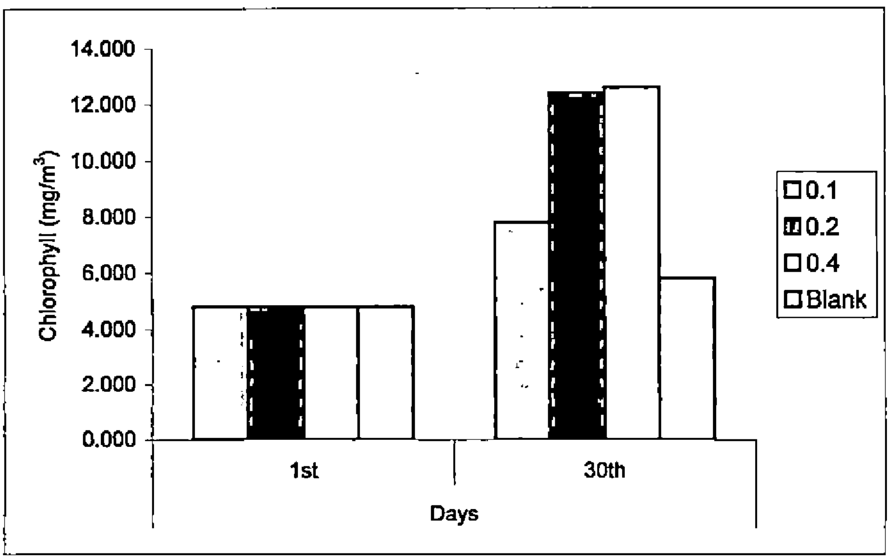

Fig.50 Variation of chlorophyll under the treatment of single super phosphate at high salinity level

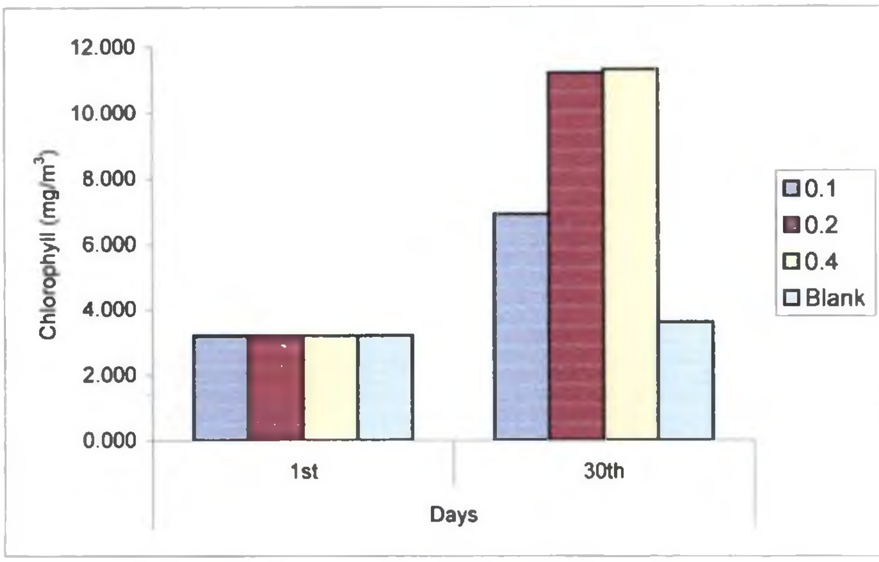

Fig.51 Variation of chlorophyll under the treatment of rock phosphate at low salinity level

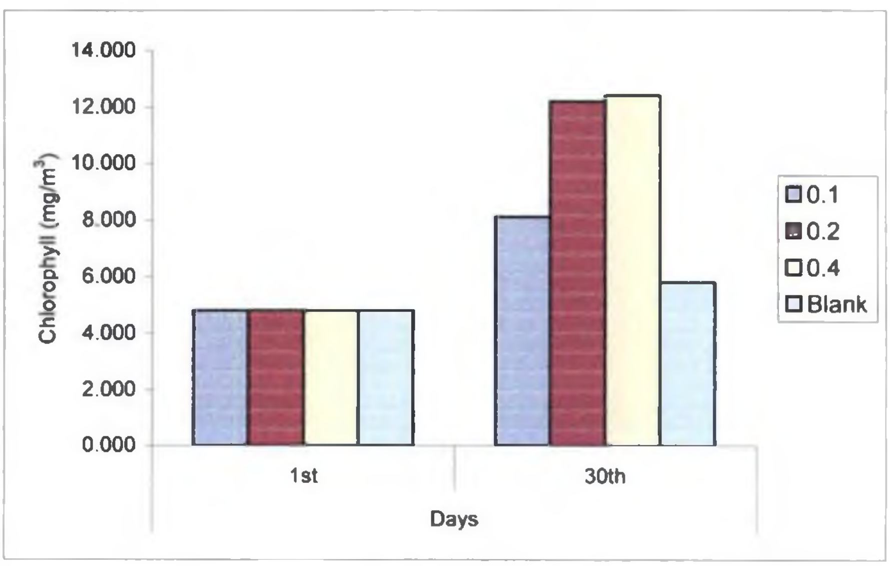

Fig.52 Variation of chlorophyll under the treatment of rock phosphate at high salinity level

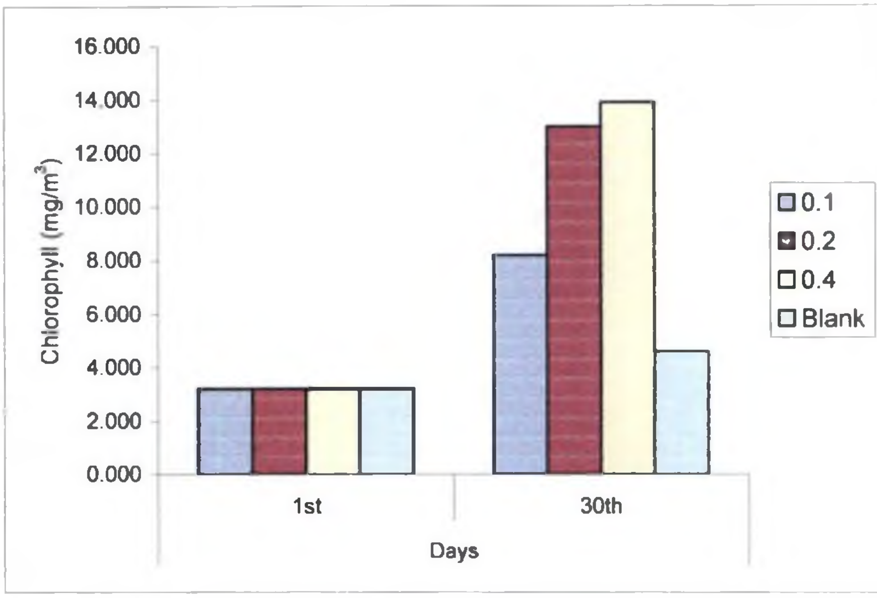

Fig.53 Variation of chlorophyll under the treatment of single super phosphate + trisodium phosphate at low salinity level

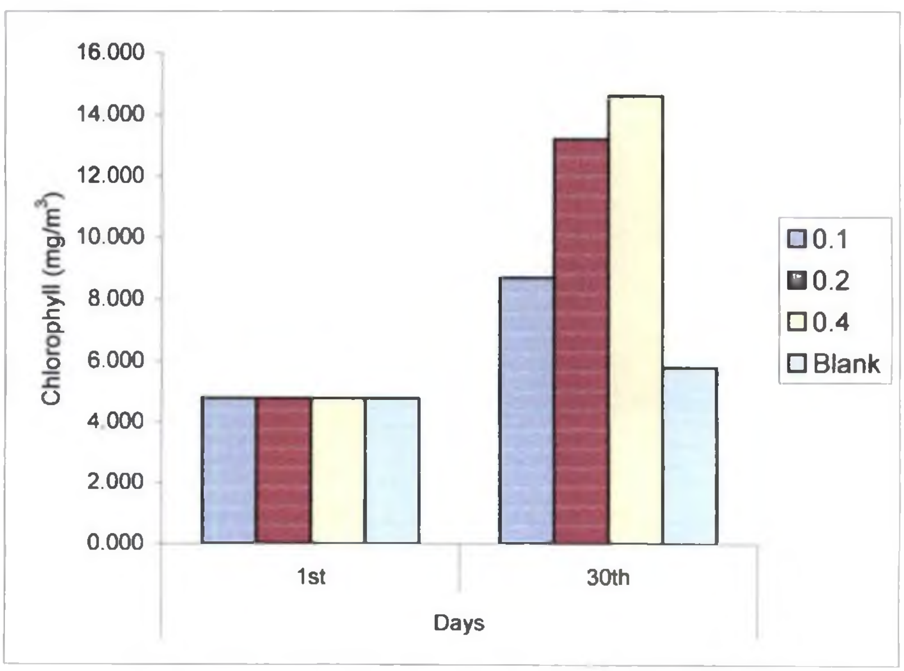

Fig.54 Variation of chlorophyll under the treatment of single super phosphate + trisodium phosphate at high salinity level

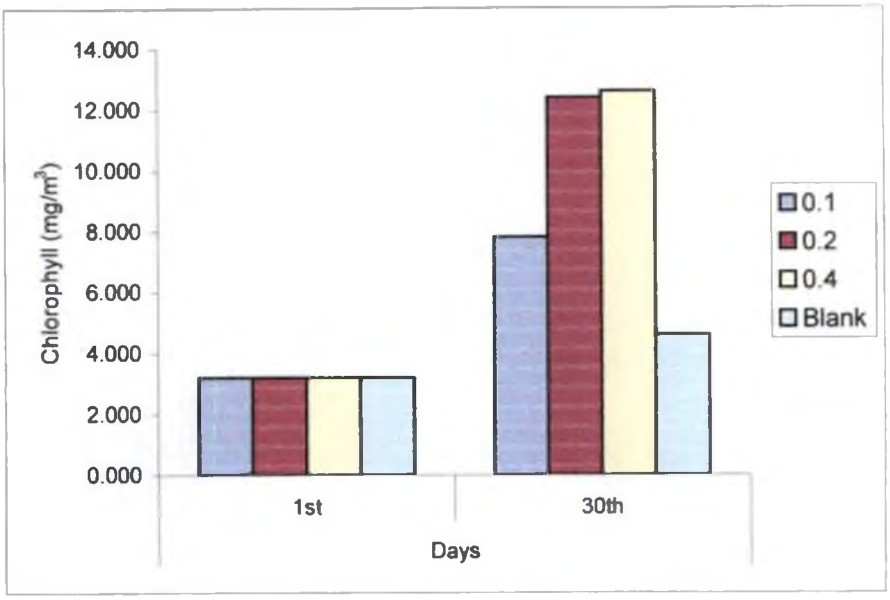

Fig.55 Variation of chlorophyll-a under the treatment of rock phosphate + trisodium phosphate at low salinity level

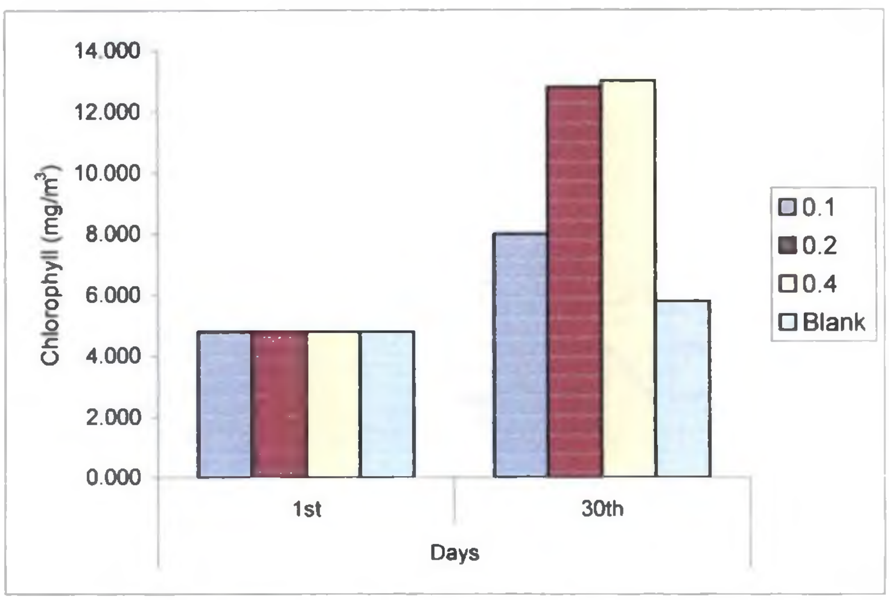

Fig.56 Variation of chlorophyll-a under the treatment of rock phosphate + trisodium phosphate at high salinity level

4. 8 Changes in the water pH levels

The pH value expresses the intensity of the acidic or basic character of water. It is defined as the negative logarithm of the hydrogen ion activity. The pH scale is usually represented as ranging from 0 – 14. High water pH, especially in combination with high dissolved calcium concentrations, favours rapid precipitation of phosphate when fertilizers are applied to ponds (Boyd and Tucker, 1998). Due to the ability of water pH to control available phosphorus levels, which is one of the main parameter under the present study ,the water pH was estimated for all the tanks on 1^{st} ,7^{th} ,14^{th} and 30^{th} days.

4.8.1 Treatment- single super phosphate

The variation of water pH under the treatment of single super phosphate at low salinity level is given in the Fig.57. For 0.1, 0.2, and 0.4ppm of phosphate- P, the water pH decreased on 7^{th} day and increased on 14^{th} and 30^{th} days. Blank also followed the same trend. The maximum value of water pH observed was 8.15, it was observed on 30^{th} day under the treatment level of 0.2 ppm of Phosphate P.

The variation of water pH under the treatment of single superphospahte at high salinity level is given in the Fig.58. For 0.1ppm of phosphate-P, an increased and similar values were observed on 7^{th} and 14^{th} days. On 30^{th} day an increased level was observed. For the level of 0.2 ppm of phosphate-P the water pH decreased on 7^{th} day and increased on 14^{th} and 30^{th} days. For 0.4ppm of phosphate-P, the water PH decreased on 7^{th} day and an increased and similar values were observed on 14^{th} and 30^{th} days. For blank the water pH increased on 7^{th} day, decreased 14^{th} day and again increased on 30^{th} day. The maximum value of water pH observed was 7.7, it was observed on 14^{th} and 30^{th} days under the treatment level of 0.4 ppm of Phosphate- P.

4.8.2 Treatment – rock phosphate

The variation of water pH under the treatment of rock phosphate at low salinity level is given in the Fig.59. For 0.1ppm of phosphate-P, the water pH increased on 7^{th} day, decreased on 14^{th} day and again increased on 30^{th} day. For 0.2ppm of phosphate-P , the water pH continuously increased on 7^{th}, 14^{th} and 30^{th} days. For 0.4ppm of phosphate- P, the water pH continuously decreased on 7^{th} and 14^{th} days but on 30^{th} day an increased value was observed. Blank also followed the same trend. The maximum value of water pH observed was 8.05, it was observed on 30^{th} day under the treatment level of 0.2 ppm of Phosphate-P.

The variation of water pH under the treatment of rock phosphate at high salinity level is given in the Fig.60. For 0.1ppm of phosphate-P , a slight decrease in pH was noted on 7^{th} day, on 14^{th} and 30^{th} days an increase was observed. For 0.2ppm of phosphate-P the pH observed on 7^{th} day was similar to that observed in first day , on 14^{th} day an increased level and on 30^{th} day a slightly decreased level was also noted. For 0.4ppm of phosphate-P, the pH decreased on 7^{th} day and increased on 14^{th} and 30^{th} days. For blank the water pH increased on 7^{th} day and decreased on 14^{th} day and again an increased level was observed on 30^{th} day The maximum value of water pH observed was 7.75, it was observed on 14^{th} day under the treatment level of 0.2 ppm of phosphate- P.

4.8.3 Treatment – single super phosphate + tri sodium phosphate

The variation of pH under the treatment of single superphospahte with tri sodium phosphate at low salinity level is given in the Fig.61. For 0.1ppm of phosphate- P, a decreased and similar level of water pH was noted on 7^{th} and 14^{th} days. On 30^{th} day the level increased. For 0.2 ppm of Phosphate- P, the water pH decreased on 7^{th} day and increased on 14^{th} and 30^{th} days. For 0.4 ppm of phosphate- P, the water pH on 7^{th} day was similar as that observed in first day. On 14^{th} and 30^{th} days an elevated and similar levels of water pH was observed. For blank a decreased and similar levels were observed on 7^{th} and 14^{th} days and an elevated level was observed on 30^{th} day. The maximum value of water pH observed was 7.95, it was observed on 30^{th} day at blank.

The variation of water pH under the treatment of single super phosphate with tri sodium phosphate at high salinity level is given in the Fig.62. For 0.1 ppm of phosphate- P, the pH was found slightly increased on 7th day, on 14th day there was a decrease in pH and on 30th day there was an increase in water pH. For the level of 0.2 ppm of phosphate-P, the water pH continuously increased on 7th, 14th and 30th days. For the level of 0.4 ppm of phosphate-P, the water pH increased on 7th day, decreased on 14th day and again increased on 30th day. Blank also followed the same trend. The maximum value of water pH observed was 7.7, it was observed on 30th day under the treatment level of 0.2 ppm of phosphate- P.

4.8.4 Treatment – rock phosphate + tri sodium phosphate

The variation of water pH under the treatment of rock phosphate with tri sodium phosphate at low salinity level is given in the Fig.63. For 0.1,0.2 and 0.4ppm of phosphate-P the water pH decreased on 7th day and increased on 14th and 30th days. Blank also followed the same trend. The maximum value of water pH observed was 7.95, it was observed on 30th day at blank.

The variation of water pH under the treatment of rock phosphate with tri sodium phosphate at high salinity level is given in the Fig.64. For the level of 0.1 ppm of phosphate-P , similar reading was observed for water pH on 1st and 7th days. On 14th day the water pH decreased and on 30th day an increased level was observed . For 0.2 ppm of phosphate–P similar values of water pH was observed for 1st , 7th and 14th days, on 30th day an increased level was observed. For the level of 0.4 ppm of phosphate-P, the water pH increased on 7th day and an increased and similar values were observed on 14th and 30th days. For blank the water pH increased on 7th day, decreased on 14th day and again increased on 30th day. The maximum value of water pH observed was 7.65, it was observed on 30th day under the treatment level of 0.2 ppm of phosphate- P.

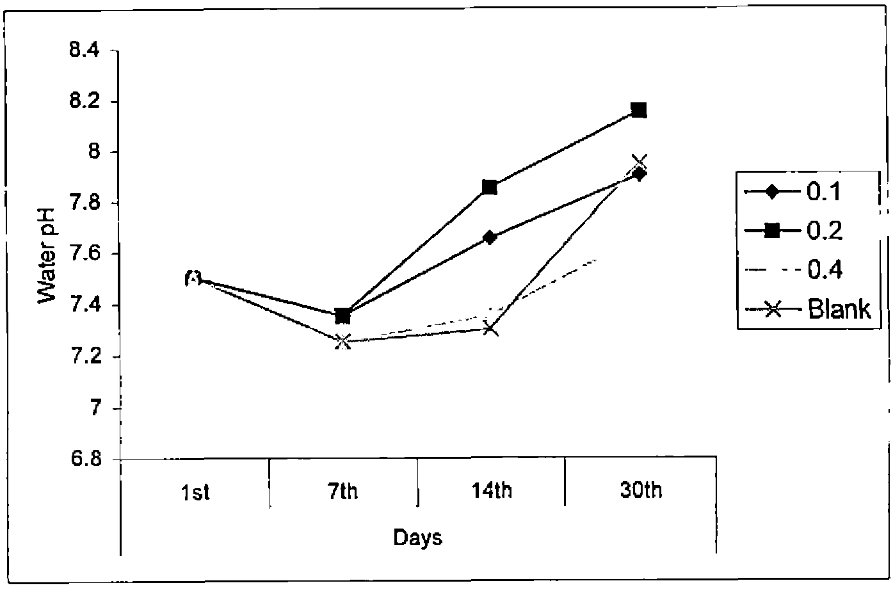

Fig.57 Variation of water pH under the treatment of single super phosphate at low salinity level

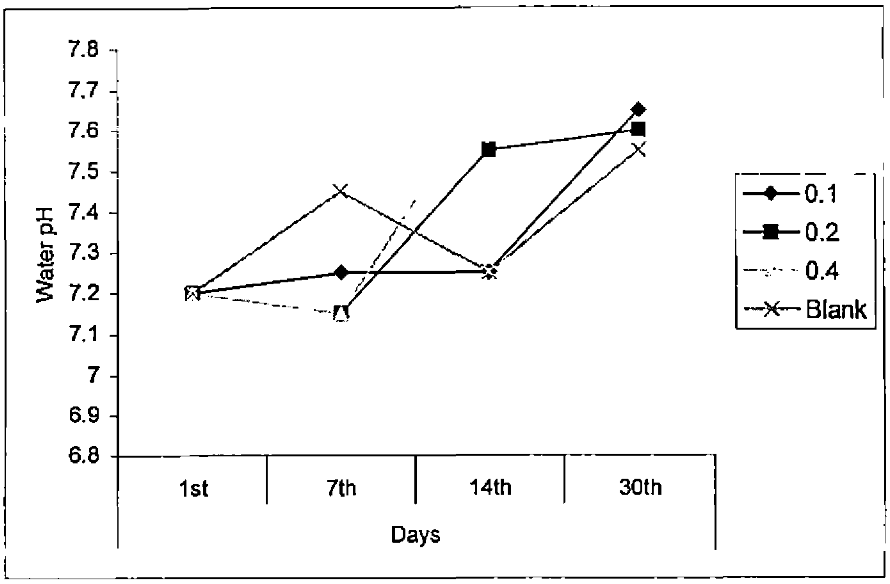

Fig.58 Variation of water pH under the treatment of single super phosphate at high salinity level

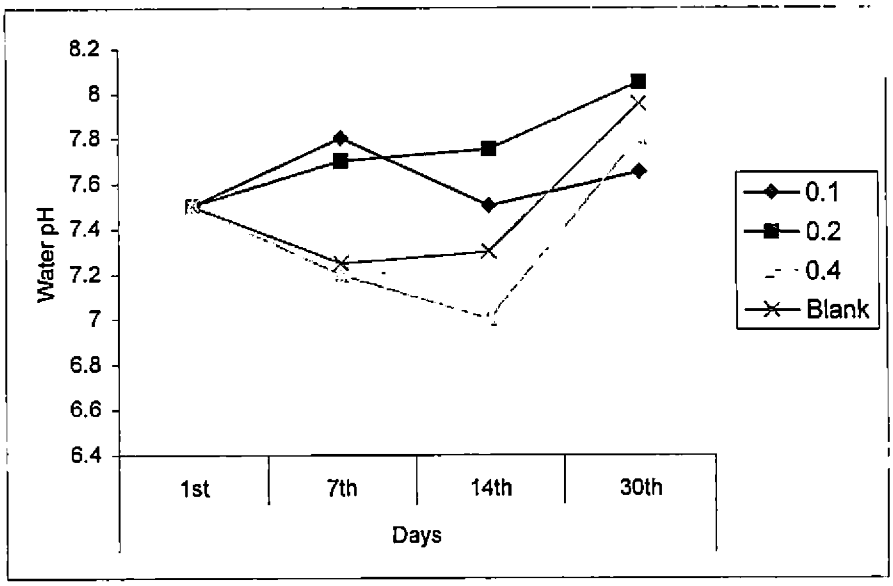

Fig.59 Variation of water pH under the treatment of rock phosphate at low salinity level

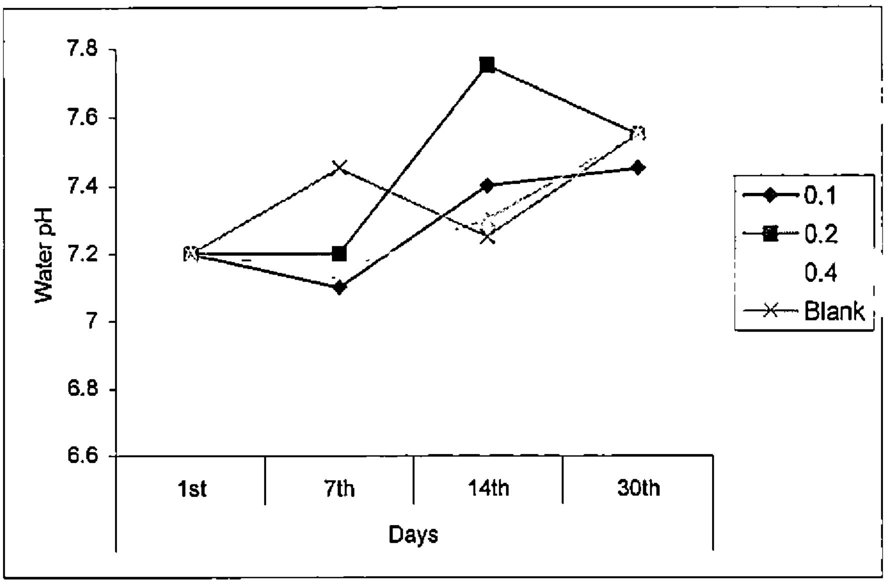

Fig.60 Variation of water pH under the treatment of rock phosphate at high salinity level

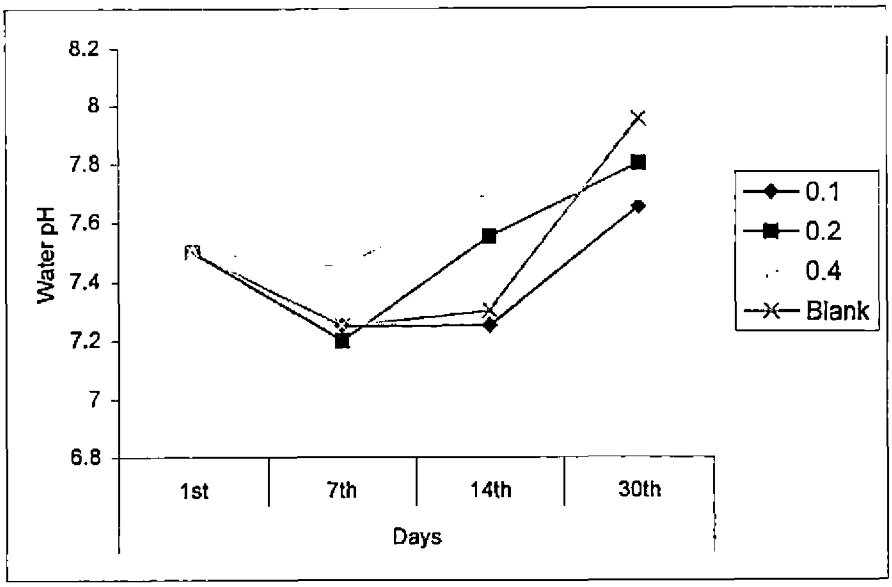

Fig.61 Variation of water pH under the treatment of single super phosphate + trisodium phosphate at low salinity level

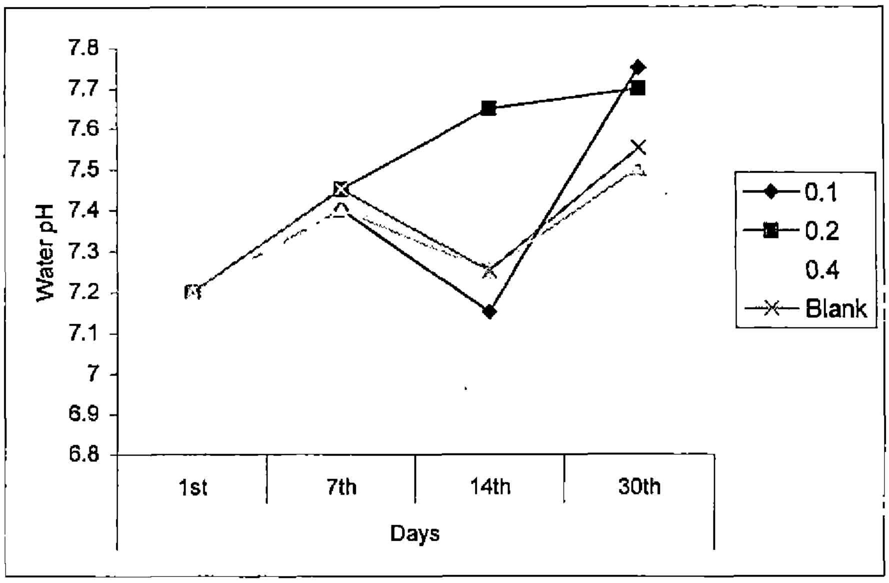

Fig.62 Variation of water pH under the treatment of single super phosphate + trisodium phosphate at high salinity lev

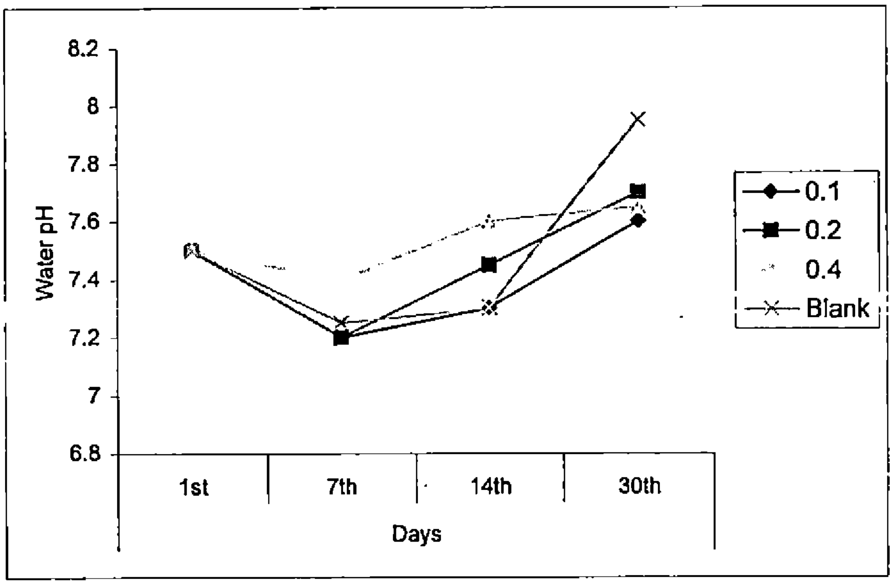

Fig.63 Variation of water pH under the treatment of rock phosphate + trisodium phosphate at low salinity level

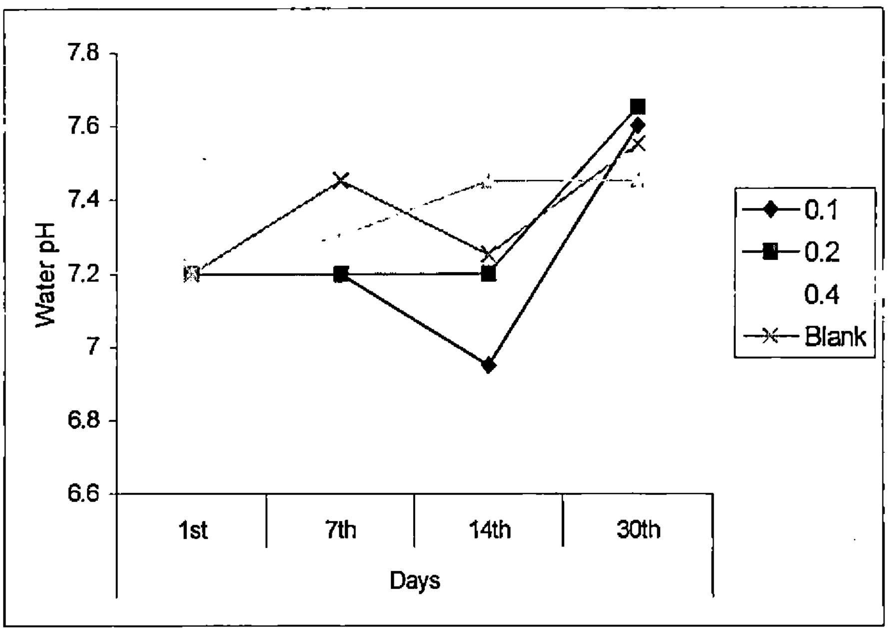

Fig.64 Variation of water pH under the treatment of rock phosphate + trisodium phosphate at high salinity leve

4.9 Changes in the dissolved oxygen levels.

The availability of dissolved oxygen frequently limits the activities and growth of aquatic animals. If dissolved oxygen concentrations are consistently low, aquatic animals will not eat or grow well and will be susceptible to infectious diseases. If concentrations fall to very low levels, the animal may die (Boyd and Tucker, 1998). In the present study the dissolved oxygen concentrations in all the tanks were estimated on 1^{st} ,7^{th} ,14^{th} and 30^{th} days.

4.9.1 Treatment- single super phosphate.

The variation of dissolved oxygen under the treatment of Single superphospahte at low salinity level is given in the Fig.65. For the level of 0.1 ppm of phosphate-P, there was a sharp increase in the dissolved oxygen level on 7^{th} day and the level increases on 14^{th} day also, but on 30^{th} day there was a decrease in the dissolved oxygen level. For the level of 0.2 ppm of phosphate-P , there was an increase in the dissolved oxygen level on 7^{th} day and this level continues on 14^{th} day also. On 30^{th} day there was a decrease in the dissolved oxygen level. For the level of 0.4 ppm of phosphate-P the dissolved oxygen level increased on 7^{th} day and the dissolved oxygen level slightly decreased on 14^{th} day and on 30^{th} day the level again decreased. For blank the dissolved oxygen increased on 7^{th} day and decreased continuously on 14^{th} and 30^{th} days. The maximum value of dissolved oxygen observed was 7.84 ppm, it was observed on 14^{th} day under the treatment level of 0.1 ppm of Phosphate- P.

The variation of dissolved oxygen under the treatment of single superphospahte at high salinity level is given in the Fig.66. For 0.1,0.2 and 0.4 ppm of phosphate-P the dissolved oxygen level increased on 7^{th} and 14^{th} days and the level decreased on 30^{th} day for all these treatments. Blank also followed the same trend. The maximum value of dissolved oxygen observed was 7.98 ppm and it was observed on 14^{th} day under the treatment level of 0.1 ppm of phosphate -P.

4.9.2 Treatment-rock phosphate.

The variation of dissolved oxygen under the treatment of rock phosphate at low salinity level is given in the Fig.67. For the level of 0.1 ppm of phosphate-P, the dissolved oxygen increased on 7^{th} and 14^{th} days, but on 30^{th} day the level decreased. For the level of 0.2 ppm of phosphate-P, the dissolved oxygen level increased on 7^{th} day and decreased on 14^{th} and 30^{th} days. For the level of 0.4 ppm of phosphate-P the dissolved oxygen increased on 7^{th} day, there was a slight increase on 14^{th} day also, but on 30^{th} day the dissolved oxygen level decreased. For blank the dissolved oxygen increased on 7^{th} day and decreased on 14^{th} and 30^{th} days. The maximum value of dissolved oxygen observed was 7.84 ppm, it was observed on 14^{th} day under the treatment level of 0.1 ppm of phosphate- P.

The variation of dissolved oxygen under the treatment of rock phosphate at high salinity level is given in the Fig.68. For the levels of 0.1,0.2 and 0.4 ppm of phosphate-P , the dissolved oxygen level continuously increased on 7^{th} and 14^{th} days, on 30^{th} day the level decreased . Blank also followed the same trend. The maximum value of dissolved oxygen observed was 7.98 ppm, it was observed on 14^{th} day under the treatment level of 0.1 ppm of phosphate- P.

4.9.3 Treatment – single super phosphate + tri sodium phosphate

The variation of dissolved oxygen under the treatment of single super phosphate with tri sodium phosphate at low salinity level is given in the Fig.69. For 0.1, 0.2 and 0.4 ppm of phosphate- P, the dissolved oxygen rapidly increased on 7^{th} day and decreased on 14^{th} and 30^{th} days. Blank also followed the same trend. The maximum value of dissolved oxygen observed was 7.02 ppm ,it was observed on 7^{th} day at blank.

The variation of dissolved oxygen under the treatment of single super phosphate with tri sodium phosphate at high salinity level is given in the Fig.70. For 0.1, 0.2 and 0.4 ppm of phosphate- P, the dissolved oxygen increased on 7^{th} and 14^{th} days and for all these treatment levels the dissolved oxygen level decreased on 30^{th} day. Blank also followed the same trend. The maximum value of dissolved oxygen observed was 7.15 ppm, it was observed on 14^{th} day under the treatment level of 0.2 ppm of phosphate- P

4.9.4 Treatment – rock phosphate + tri sodium phosphate

The variation of dissolved oxygen under the treatment of rock phosphate with tri sodium phosphate at low salinity level is given in the Fig.71. For 0.1, 0.2 and 0.4 ppm of phosphate-P , the dissolved oxygen level increased on 7^{th} day and continuously decreased values were observed on 14^{th} 30^{th} days for all these treatments. Blank also followed the same trend. The maximum value of dissolved oxygen observed was 7.71 ppm, it was observed on 7^{th} day under the treatment level of 0.2 ppm of phosphate- P.

The variation of dissolved oxygen under the treatment of rock phosphate with tri sodium phosphate at high salinity level is given in the Fig.72. For the levels of 0.1, 0.2 and 0.4 ppm of phosphate- P, there was an increase in the dissolved oxygen values on 7^{th} day, on 14^{th} day the values again increased and on 30^{th} day decreased dissolved oxygen values were observed for all these treatments. Blank also followed the same trend. The maximum value of dissolved oxygen observed was 7.29 ppm, it was observed on 14^{th} day under the treatment level of 0.1 ppm of phosphate- P.

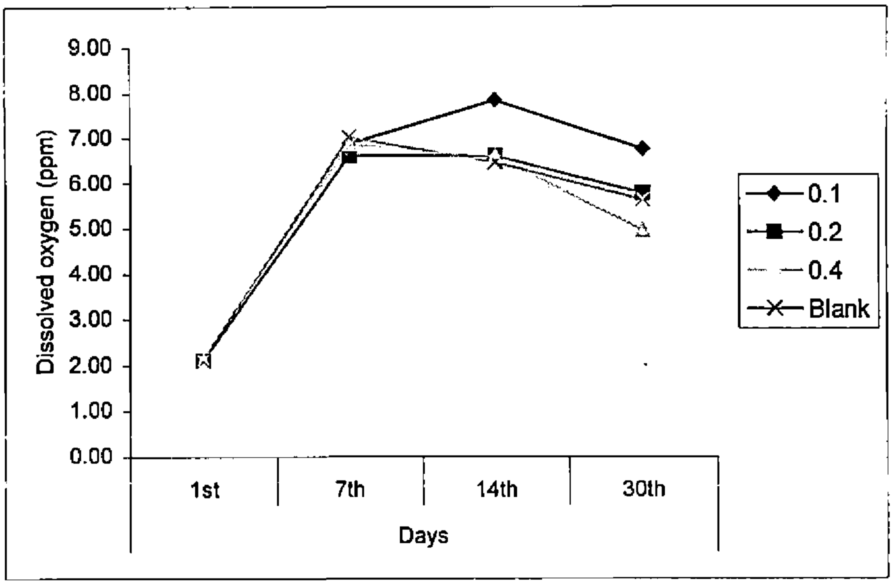

Fig.65 Variation of dissolved oxygen under the treatment of single super phosphate at low salinity level

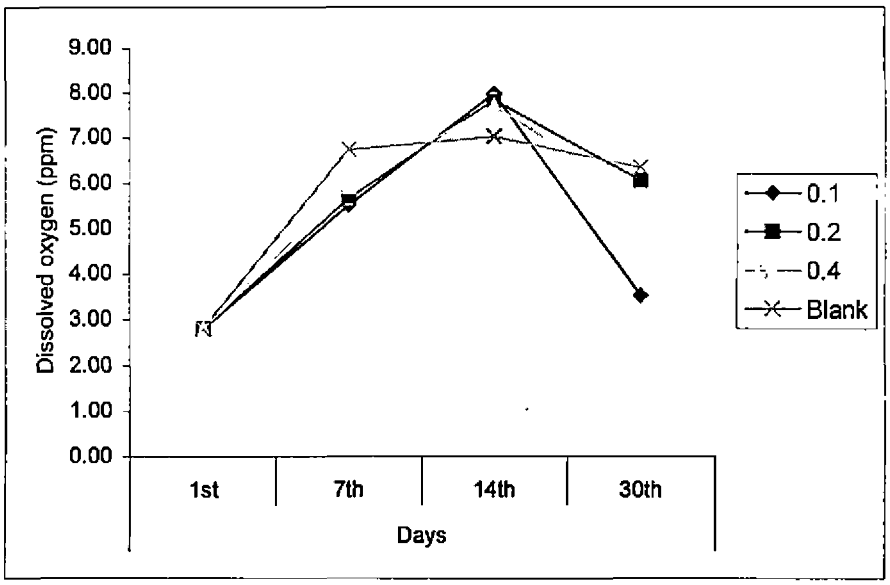

Fig.66 Variation of dissolved oxygen under the treatment of single super phosphate at high salinity level

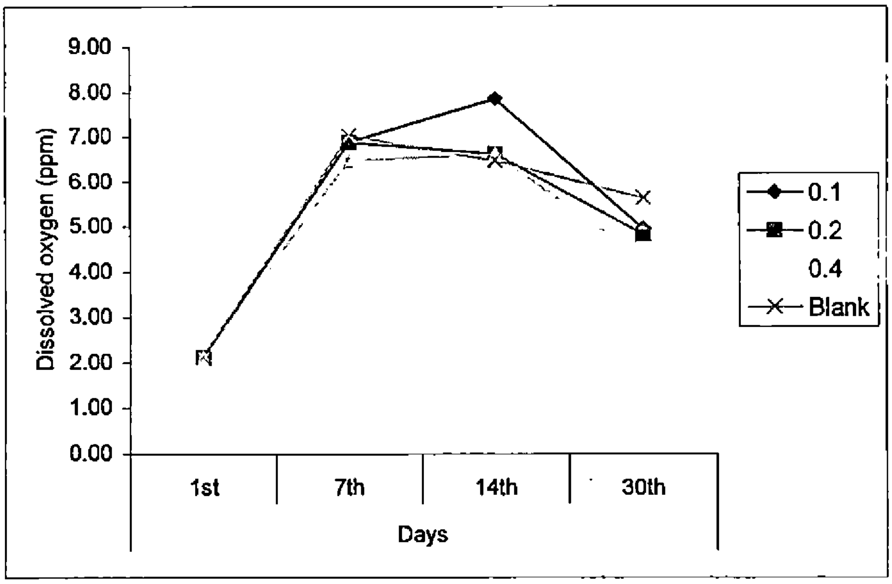

Fig.67 Variation of dissolved oxygen under the treatment of rock phosphate at low salinity level

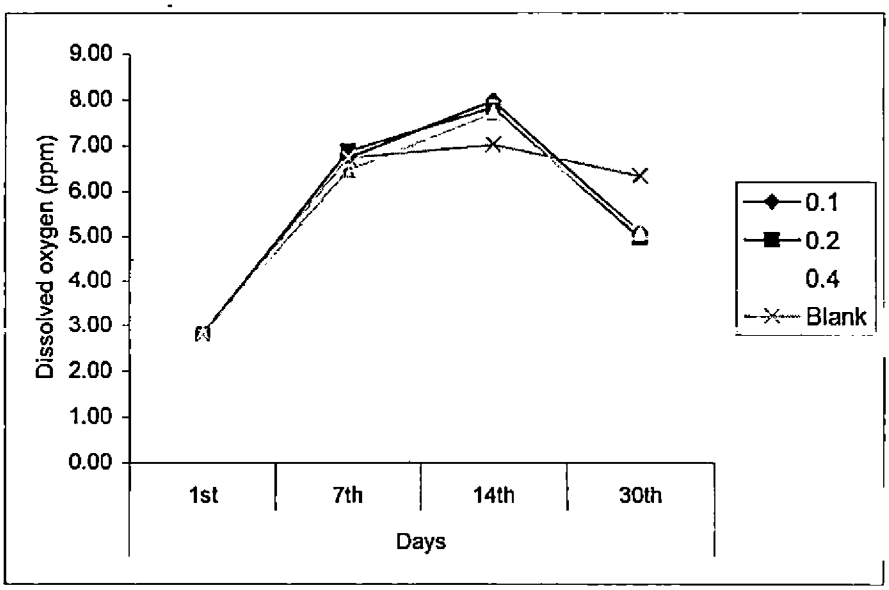

Fig.68 Variation of dissolved oxygen under the treatment of rock phosphate at high salinity level

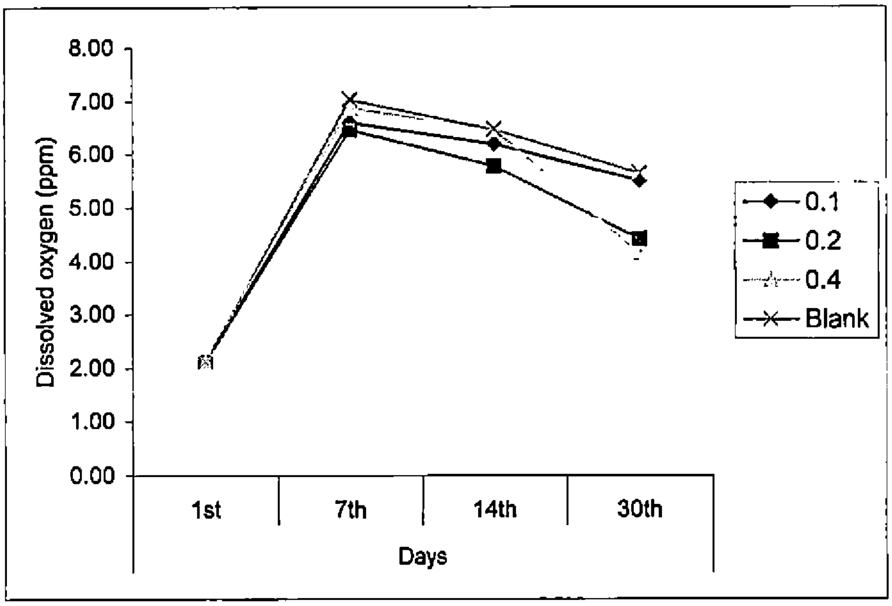

Fig.69 Variation of dissolved oxygen under the treatment of single super phosphate+trisodium phosphate at low salinity level

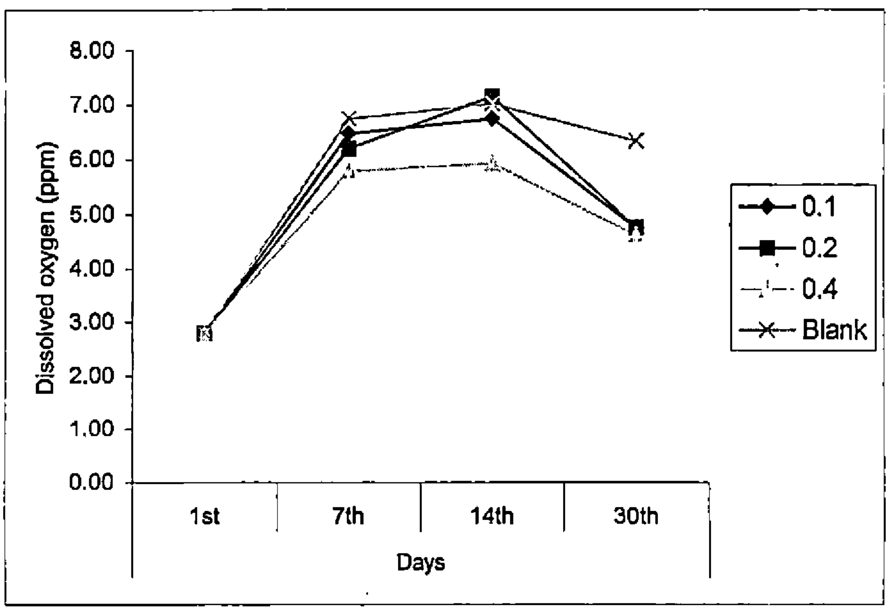

Fig.70 Variation of dissolved oxygen under the treatment of single super phosphate + trisodium phosphate at high salinity level

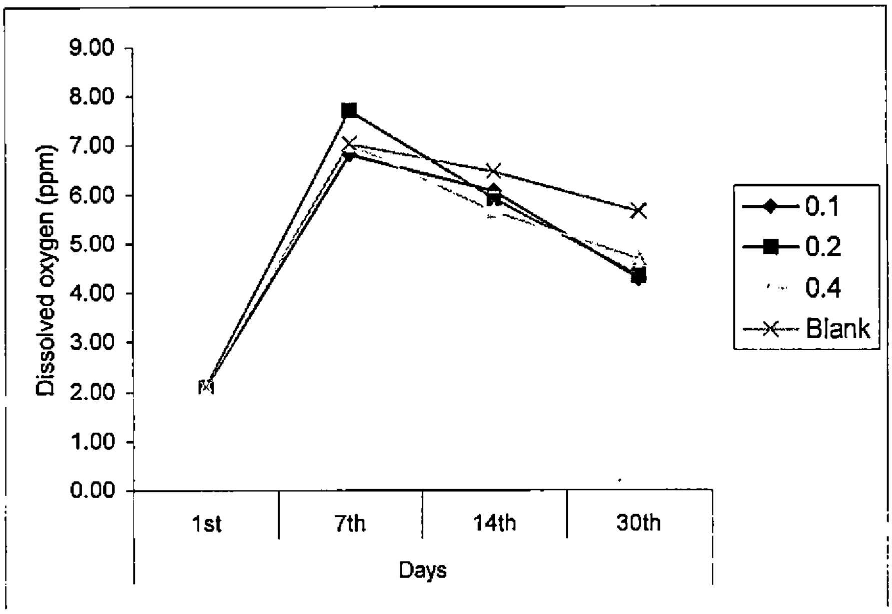

Fig.71 Variation of dissolved oxygen under the treatment of rock phosphate + trisodium phosphate at low salinity level

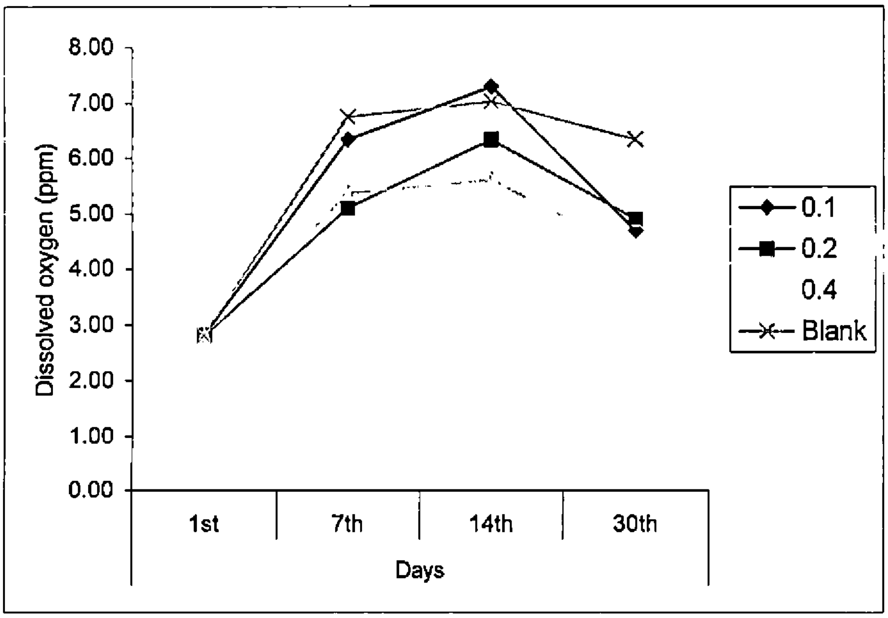

Fig.72 Variation of dissolved oxygen under the treatment of rock phosphate + trisodium phosphate at high salinity level

4.10. Changes in the carbon dioxide levels.

Carbon dioxide is a highly water soluble and biologically active gas. Carbon dioxide is produced in respiration and consumed in photosynthesis. Thus the concentration of dissolved carbon dioxide usually vary inversely with dissolved oxygen. Dissolved carbon dioxide is of interest in aquaculture because it influences the pH of water, it is a nutrient required for plant growth and its availability may limit primary productivity in some water bodies (Boyd and Tucker 1998). In the present study the carbon dioxide concentrations in all the tanks were estimated on 1^{st} ,7^{th} ,14^{th} and 30^{th} days.

4.10.1 Treatment- single super phosphate

The variation of carbon dioxide under the treatment of single super phosphate at low salinity level is given in the Fig.73. For 0.1, 0.2 and 0.4 ppm of phosphate-P, the carbon dioxide level increased on 7^{th} day and then decreased on 14^{th} and 30^{th} days. For blank the carbon dioxide level continuously decreased on 7^{th} , 14^{th} and 30^{th} days. The maximum value of carbon dioxide observed was 36.96 ppm, it was observed on 7^{th} day under the treatment levels of 0.2 and 0.4 ppm of phosphate- P

The variation of carbon dioxide under the treatment of single super phosphate at high salinity level is given in the Fig.74. For 0.1 , 0.2 and 0.4 ppm of phosphate-P, the carbon dioxide level continuously decreased on 7^{th}, 14^{th} and 30^{th} days. For blank the carbon dioxide level increased on 7^{th} day and then decreased on 14^{th} and 30^{th} days. The maximum value of carbon dioxide observed was 33 ppm, it was observed on 7^{th} day in blank.

4.10.2 Treatment- rock phosphate

The variation of carbon dioxide under the treatment of rock phosphate at low salinity level is given in the Fig.75. For the treatment doses 0.2 and 0.4 ppm and also for blank, the carbon dioxide level decreased on 7^{th} ,14^{th} and 30^{th} days. For the treatment dose of 0.1 ppm, the carbon dioxide level continued almost static on 7^{th} day and then showed a decrease on 14^{th} and 30^{th} days. The maximum value of carbon dioxide observed was 26 ppm and it was observed on 7^{th} day for the treatment dose of 0.1 ppm of phosphate-P.

The variation of carbon dioxide under the treatment of rock phosphate at high salinity level is given in the Fig.76. For the treatment dose of 0.4 ppm and blank, the carbondioxide level increased on 7^{th} day and then decreased on 14^{th} and 30^{th} days. But for the treatment doses of 0.1 and 0.2 ppm of phosphate-P, the carbondioxide level continuously decreased on 7^{th}, 14^{th} and 30^{th} days. The maximum value of carbon dioxide observed was 33 ppm, it was observed on 7^{th} day in blank.

4.10.3 Treatment - single superphosphate + tri sodium phosphate

The variation of carbon dioxide under the treatment of single super phosphate with tri sodium phosphate at low salinity level is given in the Fig.77. For 0.1 ppm of phosphate–P, carbon dioxide level increased on 7^{th} day and thereafter continuously decreased on 14^{th} and 30^{th} days. For the treatment doses 0.2 and 0.4 ppm and also for blank, the carbon dioxide level continuously decreased on 7^{th} , 14^{th} and 30^{th} days. The maximum value of carbon dioxide observed was 30 ppm, it was observed on 7^{th} day for the treatment dose of 0.1 ppm of phosphate-P.

The variation of carbon dioxide under the treatment of single super phosphate with trisodium phosphate at high salinity level is given in the Fig.78. For the treatment doses of 0.1 and 0.2 ppm and also for blank the carbondioxide level increased on 7^{th} day and then decreased on 14^{th} and 30^{th} days. For the treatment dose of 0.4 ppm, the level was found continuously decreasing on 7^{th} , 14^{th} and 30^{th} days. The maximum value of carbon dioxide observed was 37 ppm, it was observed on 7^{th} day for the treatment dose of 0.1 ppm of phosphate-P.

4.10.4 Treatment – rock phosphate + trisodium phosphate

The variation of carbon dioxide under the treatment of rock phosphate with tri sodium phosphate at low salinity level is given in the Fig.79. For the treatment doses of 0.1, 0.2 and 0.4 ppm and also for blank, the carbon dioxide level continuously decreased on 7th , 14th and 30th days. The maximum value of carbon dioxide observed was 25 ppm and it was observed on 1st day.

The variation of carbon dioxide under the treatment of rock phosphate with trisodium phosphate at high salinity level is given in the Fig.80. For the treatment doses of 0.1 and 0.2 ppm and also for blank, the carbon dioxide level increased on 7th day and decreased on 14th and 30th days. For 0.4 ppm dose the carbon dioxide level remained almost same on 7th day and then decreased continuously on 14th and 30th days. The maximum value of carbon dioxide observed was 33 ppm, it was observed on 7th day in blank.

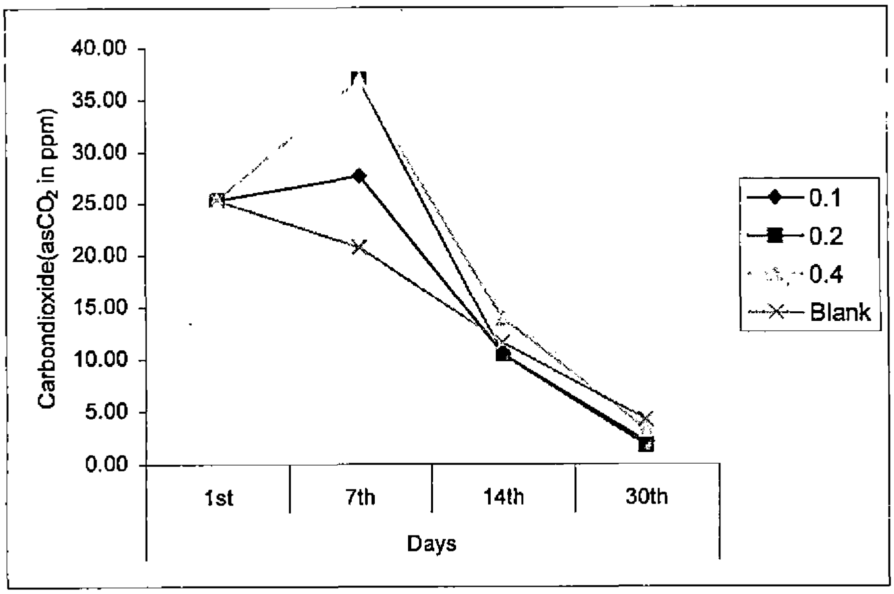

Fig.73 Variation of carbondioxide under the treatment of single super phosphate at low salinity level

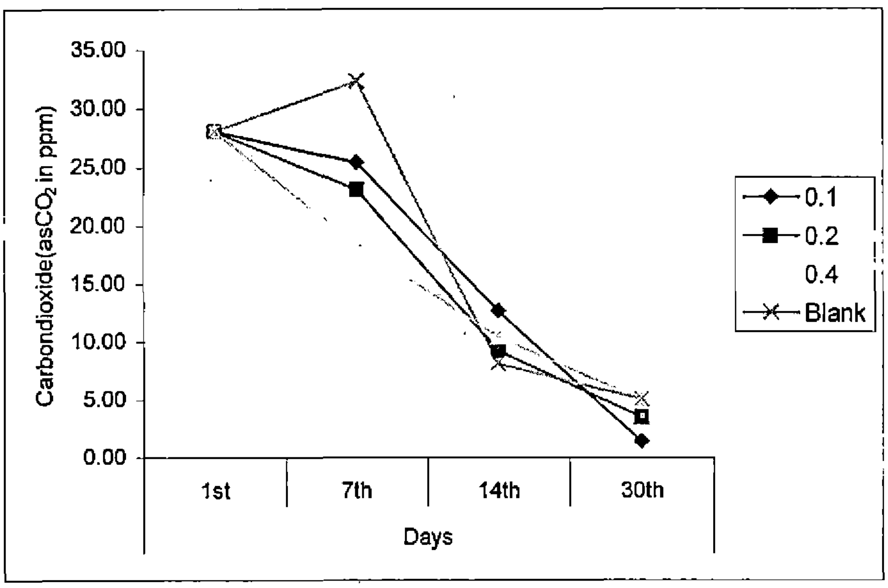

Fig.74 Variation of carbondioxide under the treatment of single super phosphate at high salinity level

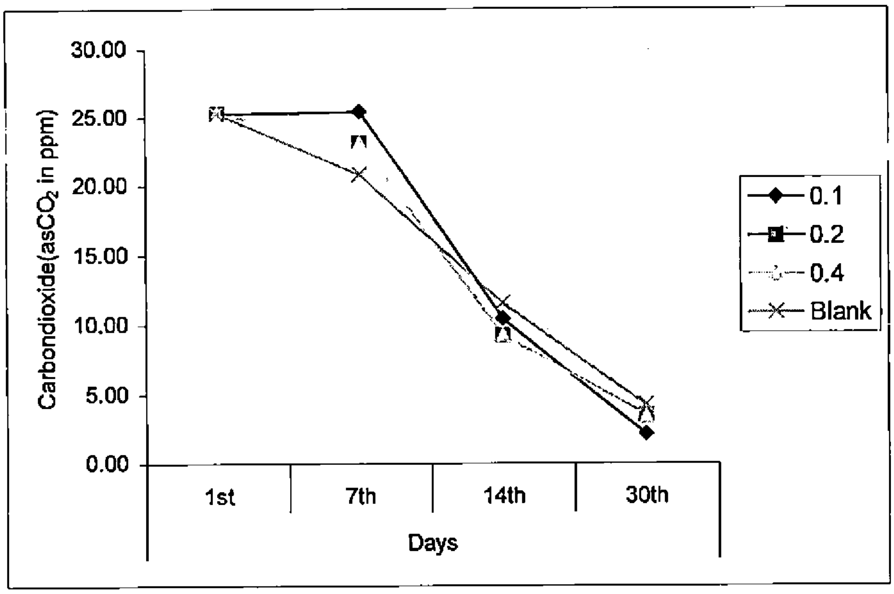

Fig.75 Variation of carbondioxide under the treatment of rock phosphate at low salinity level

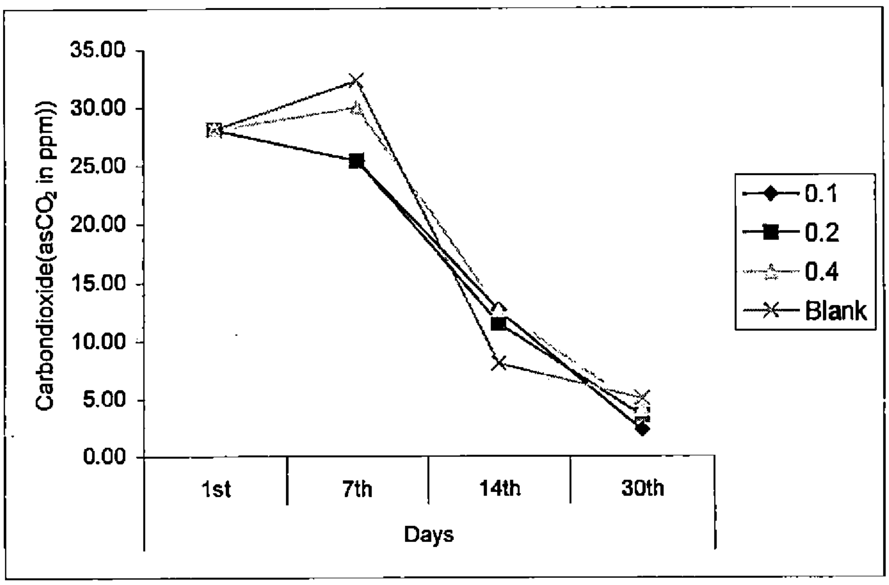

Fig.76 Variation of carbondioxide under the treatment of rock phosphate at high salinity level

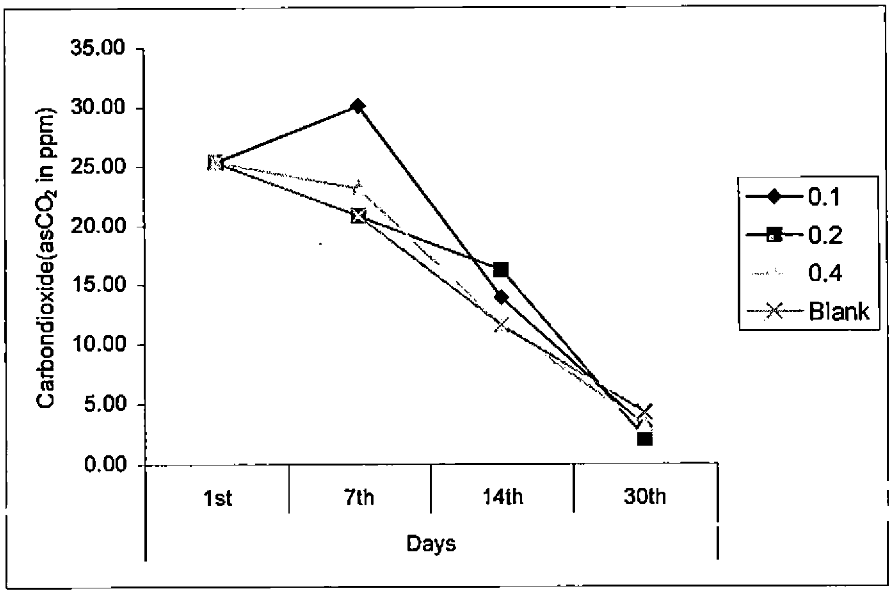

Fig.77 Variation of carbondioxide under the treatment of single super phosphate + trisodium phosphate at low salinity level

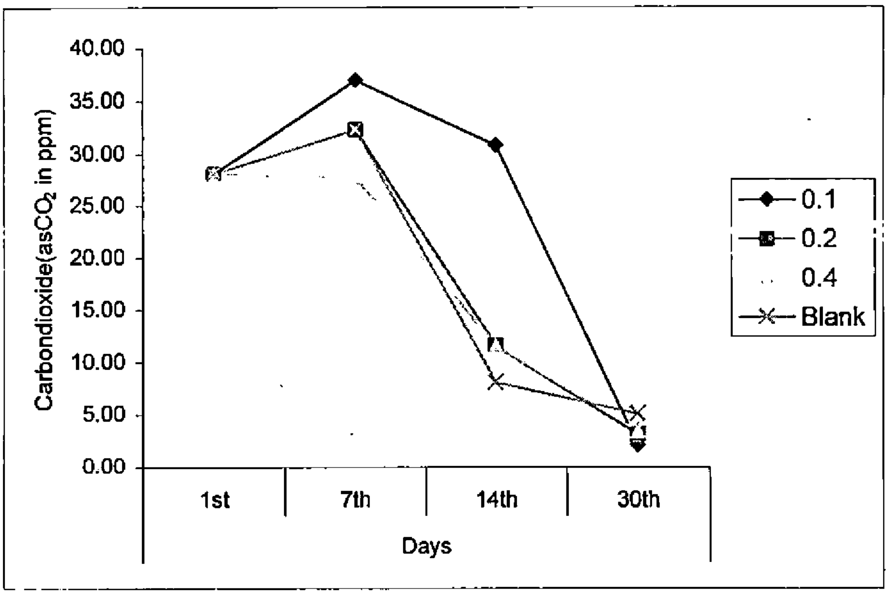

Fig.78 Variation of carbondioxide under the treatment of single super phosphate + trisodium phosphate at high salinity level

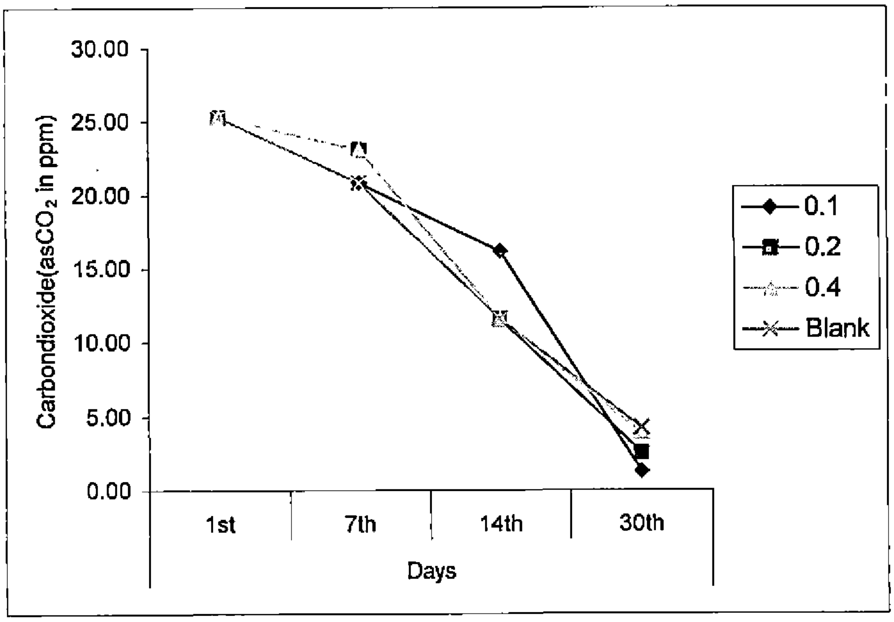

Fig.79 Variation of carbondioxide under the treatment of rock phosphate + trisodium phosphate at low salinity level

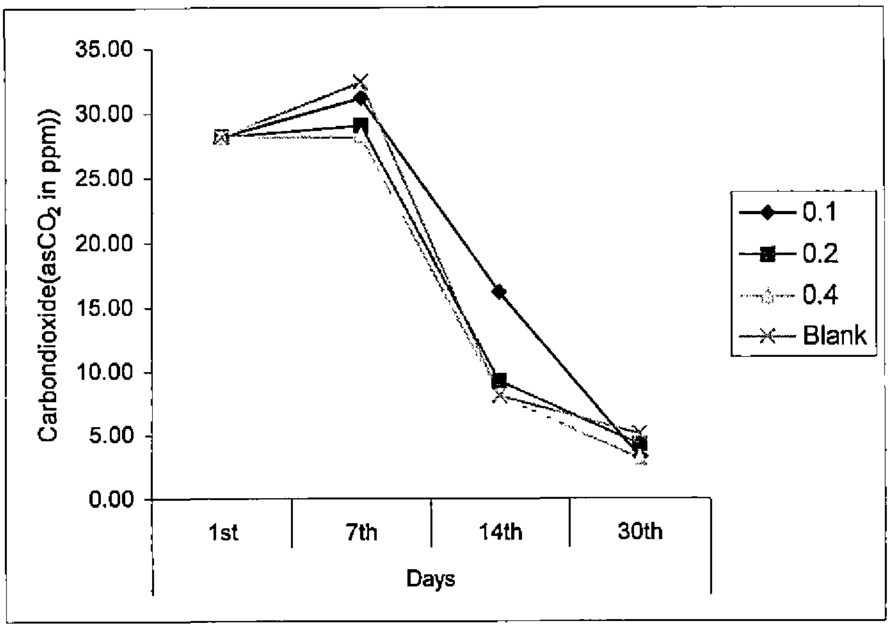

Fig.80 Variation of carbondioxide under the treatment of rock phosphate + trisodium phosphate at high salinity level

4.11 Changes in the total alkalinity levels

Alkalinity is a measure of the bases that are titratable with strong acid, it can be thought of as the acid neutralizing capacity (Valiela, 1984). The benefits due to the presence of ample alkalinity in waters include buffering of water against changes in pH, enhanced natural fertility of waters and decreased potential for metal toxicity (Boyd and Tucker, 1998). In the present study, the alkalinity was estimated in all the tanks on 1st ,7th ,14th and 30th days.

4.11.1 Treatment-single super phosphate

The variation of total alkalinity under the treatment of single super phosphate at low salinity level is given in the Fig.81. For the level of 0.1 ppm of phosphate-P, total alkalinity decreased on 7th day, increased on 14th day and then again decreased on 30th day. For the treatment dose of 0.4 ppm and blank, total alkalinity level increased on 7th day, decreased on 14th day and then again increased on 30th day. For the treatment dose of 0.2 ppm of phosphate-P, the total alkalinity level slightly increased on 7th day, decreased on 14th day and then again increased on 30th day. The maximum value of total alkalinity observed was 111ppm and it was observed on 7th day in blank.

The variation of total alkalinity under the treatment of single super phosphate at high salinity level is given in the Fig.82. For the treatment dose of 0.1 ppm of phosphate-P, the total alkalinity level decreased on 7th day, increased continuously on 14th and 30th days. For 0.2 ppm, the level decreased on 7th and 14th days,but on 30th day the level increased. For the treatment dose of 0.4 ppm, the total alkalinity level decreased on 7th day and increased on 14th day. On 30th day the level slightly decreased again. The maximum value of total alkalinity observed was 140 ppm, it was observed on 30th day, for the treatment dose of 0.1 ppm.

4.11.2 Treatment – rockphosphate

The variation of total alkalinity under the treatment of rockphosphate at low salinity level is given in the Fig.83. For the treatment doses of 0.1 and 0.2 ppm of phosphate-P, the total alkalinity level continuously increased on 7th ,14th and 30th days. For the treatment dose of 0.4 ppm and blank the total alkalinity level increased on 7th day, decreased on 14th day and then again increased on 30th day. The maximum value of total alkalinity observed was 111 ppm, it was observed on 7th day in blank.

The variation of total alkalinity under the treatment of rock phosphate at high salinity level is given in the Fig.84. For the treatment doses of 0.1, 0.2 and 0.4 ppm of phosphate-P, the total alkalinity level decreased on 7th and 14th days, but on 30th day for all these treatments, the total alkalinity level increased. For blank, a decreased and almost same values were observed on 7th and 14th days, on 30th day the level again decreased slightly. The maximum value of total alkalinity observed was 139 ppm, it was observed on 1st day.

4.11.3 Treatment – single superphsophate + trisodium phosphate

The variation of total alkalinity under the treatment of single superphsophate with trisodium phosphate at low salinity level is given in the Fig.85. For the treatment dose of 0.4 ppm and blank, the total alkalinity level increased on 7th day, decreased on 14th day and then again increased on 30th day. For the dose of 0.4 ppm, the total alkalinity level increased on 7th day and decreased on 14th and 30th days. For 0.1 ppm dose the total alkalinity level decreased on 7th day and increased on 14th and 30th days. The maximum value of total alkalinity observed was 111 ppm, it was observed on 7th day in blank.

The variation of total alkalinity under the treatment of single super phosphate with trisodium phosphate at high salinity level is given in the Fig.86. For the treatment dose of 0.1 and 0.2 ppm of phosphate-P, the total alkalinity level decreased on 7th day and increased on 14th and 30th days. For the dose of 0.4 ppm, the level decreased on 7th day, increased on 14th day and then again decreased on on 30th day. For blank the total alkalinity level was found continuously decreasing on 7th, 14th and 30th days. The maximum value of total alkalinity observed was 140.5 ppm, it was observed on 30th day for the treatment dose of 0.1 ppm.

4.11.4 Treatment – rockphosphate + trisodium phosphate

The variation of total alkalinity under the treatment of rockphosphate with trisodium phosphate at low salinity level is given in the Fig.87. For the levels of 0.1 and 0.4 ppm of phosphate-P, the total alkalinity level increased on 7th and 14th days, but on 30th day the level decreased. For the level of 0.2 ppm of phosphate-P the total alkalinity level increased on 7th day, and decreased on 14th and 30th days. For blank the total alkalinity level increased on 7th day, decreased on 14th day and then again increased on 30th day. The maximum value of total alkalinity observed was 111 ppm , it was observed on 7th day in blank.

The variation of total alkalinity under the treatment of rock phosphate with tri sodium phosphate at high salinity level is given in the Fig.88. For the level of 0.1 ppm of phosphate-P, the total alkalinity level continuously decreased on 7th and 14th days and on 30th day the level increased. For 0.2 ppm, a decreased and almost similar values were observed on 7th and 14th days. On 30th day the level increased. For 0.4 ppm the total alkalinity level decreased on 7th and 14th days, the total alkalinity level on 30th day was almost similar as that on 14th day. For blank the total alkalinity level continuously decreased on 7th, 14th and 30th days. The maximum value of total alkalinity observed was 139 ppm, it was observed on 1st day.

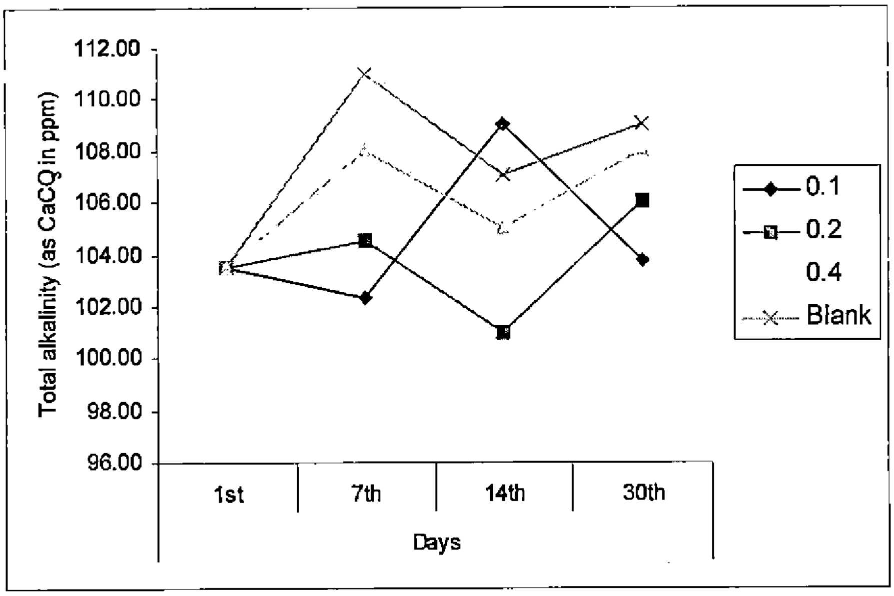

Fig.81 Variation of total alkalinity under the treatment of single super phosphate at low salinity level

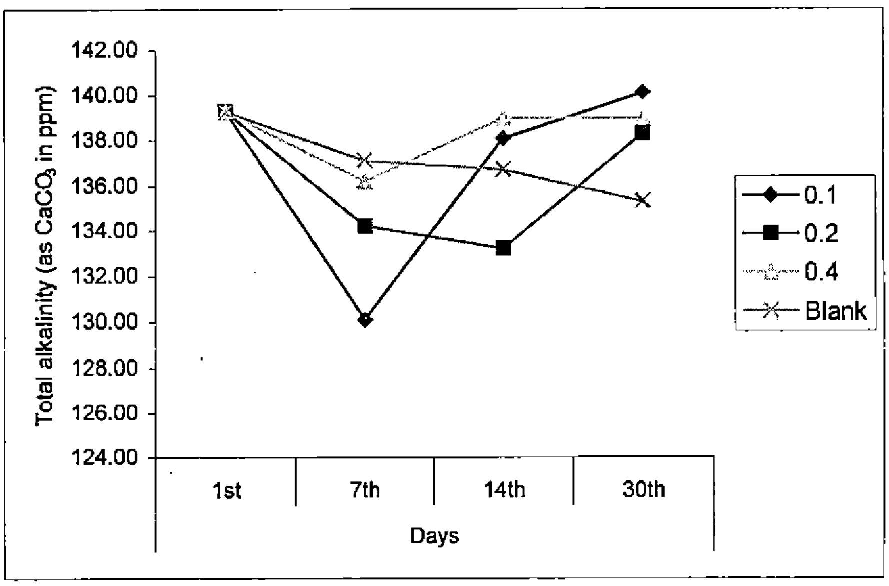

Fig.82 Variation of total alkalinity under the treatment of single super phosphate at high salinity level

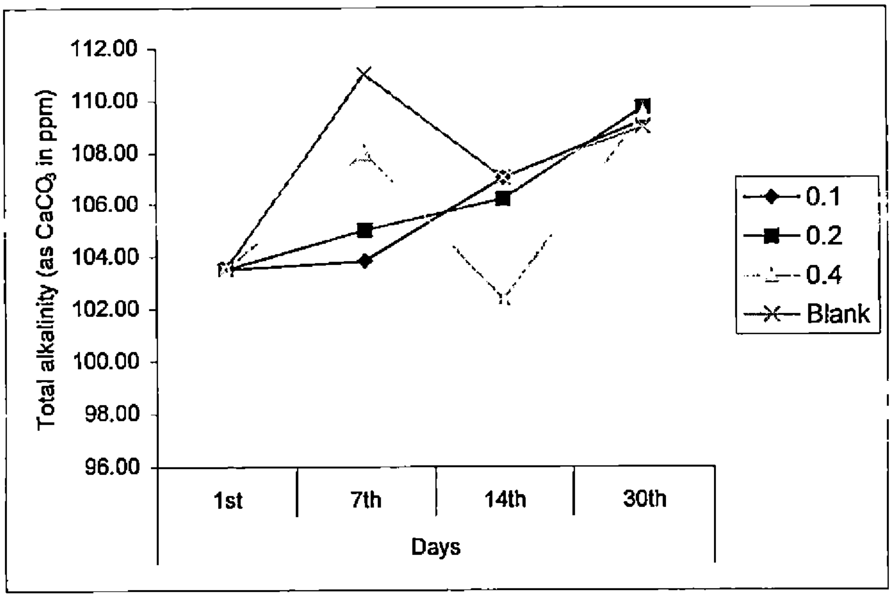

Fig.83 Variation of total alkalinity under the treatment of rock phosphate at low salinity level

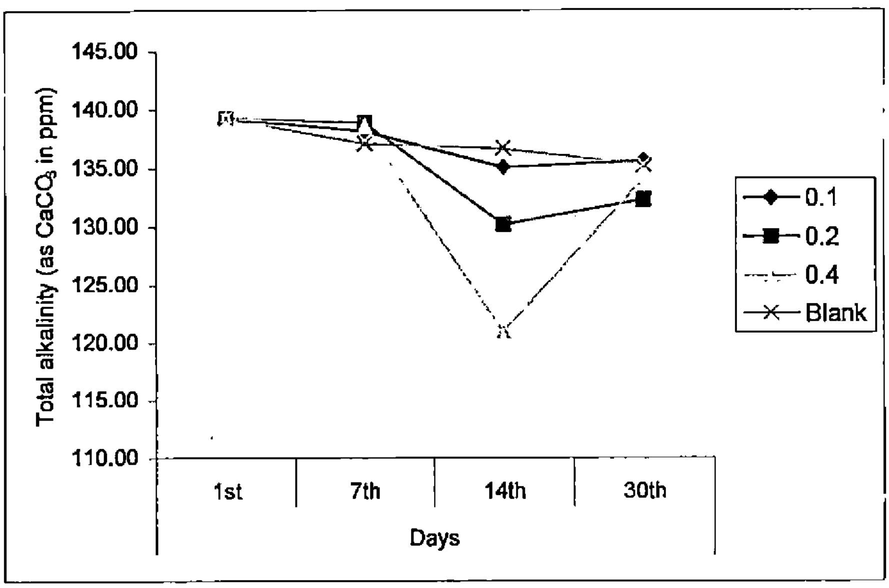

Fig.84 Variation of total alkalinity under the treatment of rock phosphate at high salinity level

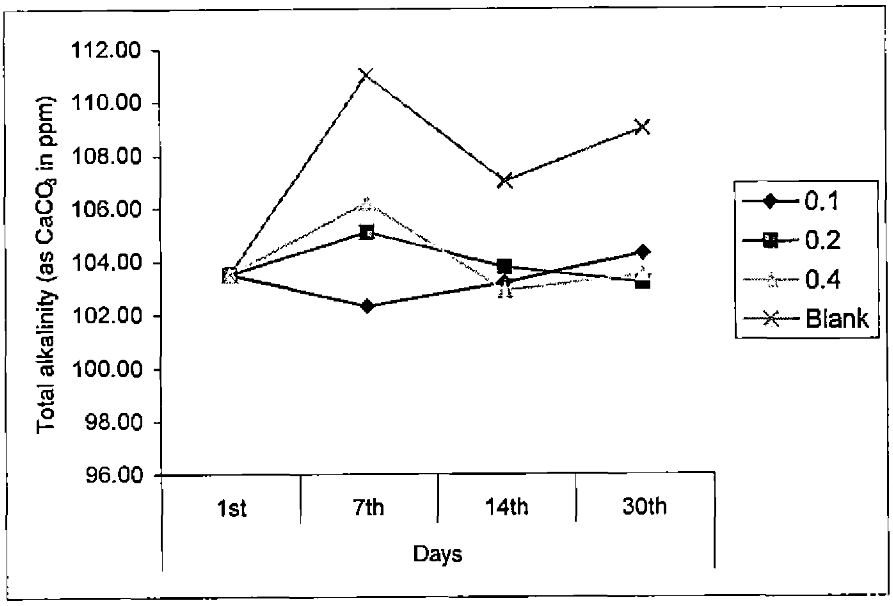

Fig.85 Variation of total alkalinity under the treatment of single super phosphate + trisodium phosphate at low salinity level

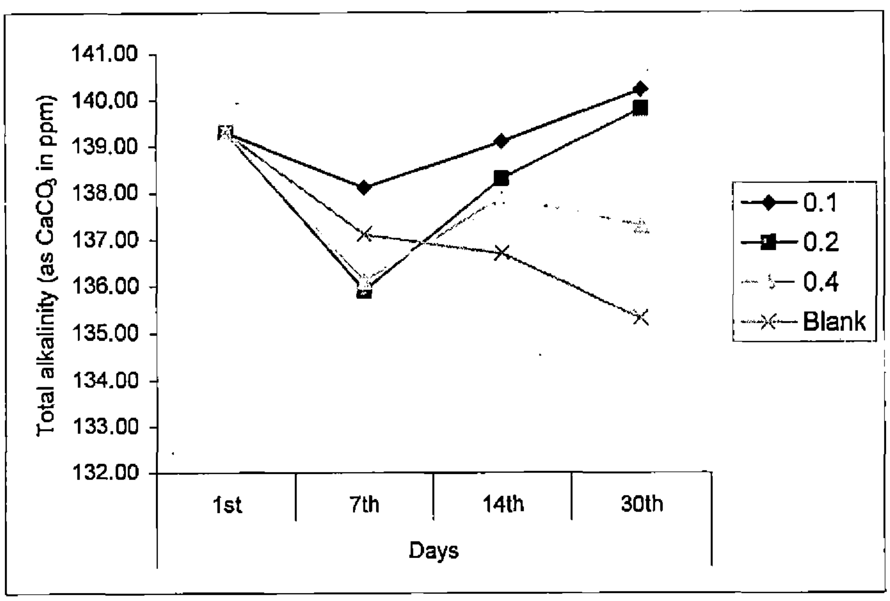

Fig.86 Variation of total alkalinity under the treatment of single super phosphate + trisodium phosphate at high salinity level

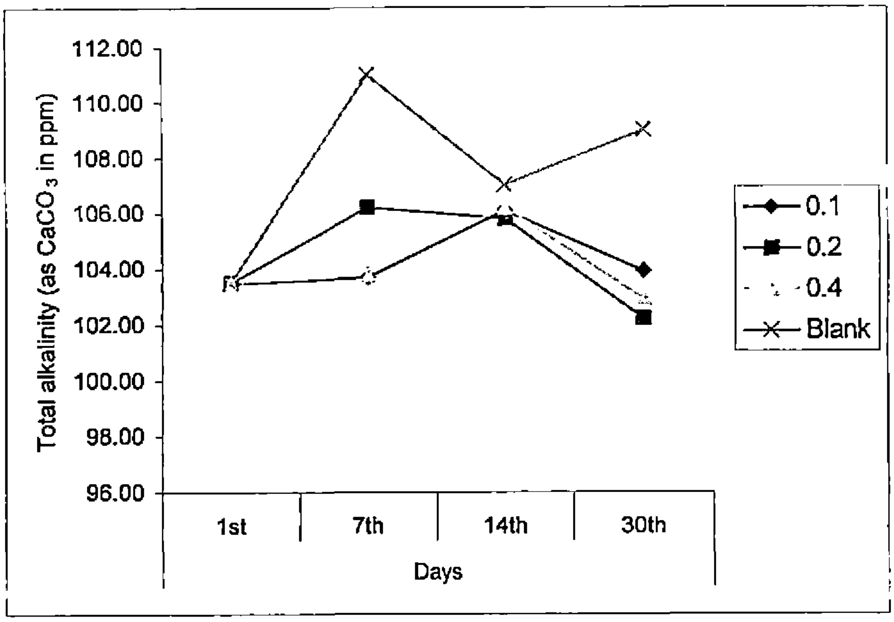

Fig.87 Variation of total alkalinity under the treatment of rock phosphate + trisodium phosphate at low salinity level

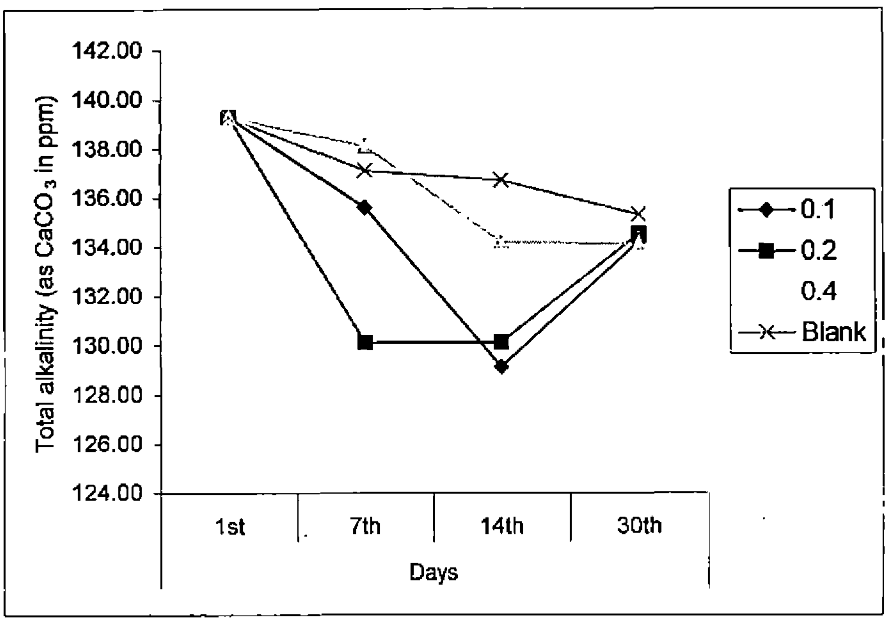

Fig.88 Variation of total alkalinity under the treatment of rock phosphate + trisodium phosphate at high salinity level

4.12 Changes in the total hardness levels

Total hardness is the sum of the concentrations of calcium and magnesium in water expressed as mg/L equivalent $CaCO_3$. Other divalent cations contribute to hardness, but their concentrations in natural waters are usually low. Total hardness is a general indicator of the degree of mineralization of water, and as total hardness increases, concentrations of most other substances (Including essential plant nutrients) tend also to increase (Boyd and Tucker, 1998). In the present study the total hardness was estimated in all the tanks on 1^{st}, 7^{th}, 14^{th} and 30^{th} days.

4.12.1 Treatment – single superphosphate

The variation of total hardness under the treatment of single super phosphate at low salinity level is given in the Fig. 89. For 0.1 and 0.2 ppm of phosphate-P, the total hardness continuously increased on 7^{th}, 14^{th} and 30^{th} days. Blank also followed the same trend. For the level of 0.4 ppm of phosphate-P an increased and similar values of total hardness was observed on 7^{th} and 14^{th} days. On 30^{th} day the total hardness value again increased. The maximum value of total hardness observed was 2903.6 ppm, it was observed on 30^{th} day under the treatment level of 0.2 ppm of phosphate- P.

The variation of total hardness under the treatment of single superphospahte at high salinity level is given in the Fig.90. For 0.1, 0.2 and 0.4 ppm of phosphate-P , the total hardness decreased on 7^{th} day, on 14^{th} and 30^{th} day a continuous increase was observed for all these treatment levels. For blank the total hardness continuously increased on 7^{th}, 14^{th} and 30^{th} days. The maximum value of total hardness observed was 6118.3 ppm, it was observed on 30^{th} day at blank.

4.12.2 Treatment – rockphosphate

The variation of total hardness under the treatment of rock phosphate at low salinity level is given in the Fig.91. For 0.1, 0.2 and 0.4 ppm of phosphate-P , the total hardness continuously increased on 7^{th} 14^{th} and 30^{th}

days. Blank also followed the same trend. The maximum value of total hardness observed was 2903.6 ppm, it was observed on 30^{th} day under the treatment level of 0.2 ppm of phosphate- P

The variation of total hardness under the treatment of rock phosphate at high salinity level is given in the Fig.92. For the level of 0.1 ppm of phosphate-P, the total hardness level decreased on 7^{th} day and then again slightly decreased on 14^{th} day and finally increased on 30^{th} day. For the level of 0.2 ppm of phosphate-P, the total hardness value decreased on 7^{th} day and continuously increased on 14^{th} and 30^{th} days. For the level of 0.4 ppm of phosphate-P, the total hardness level continuously increased on 7^{th}, 14^{th} and 30^{th} days. Blank also followed the same trend. The maximum value of total hardness observed was 6118.3 ppm, it was observed on 30^{th} day at blank.

4.12.3 Treatment – single superphosphate + trisodium phosphate

The variation of total hardness under the treatment of single super phosphate with trisodium phosphate at low salinity level is given in the Fig.93. For 0.1 and 0.2 ppm of phosphate-P an increased and similar values of total hardness was observed on 7^{th} and 14^{th} days. On 30^{th} day, the values again increased. For 0.4ppm of phosphate-P, the total hardness values continuously increased on 7^{th}, 14^{th} and 30^{th} days. Blank also followed the same trend. The maximum value of total hardness observed was 2877.68 ppm, it was observed on 30^{th} day under the treatment level of 0.2 ppm of phosphate-P.

The variation of total hardness under the treatment of single super phosphate with trisodium phosphate at high salinity level is given in the Fig.94. For the level of 0.1 ppm of phosphate-P , a decreased and similar value of total hardness was observed On 7^{th} and 14^{th} days. On 30^{th} day the value increased. For the level of 0.2 ppm of phosphate-P , the total hardness level decreased on 7^{th} day and continuously increased on 14^{th} and 30^{th} days. For 0.4 ppm of phosphate-P, the total hardness value continuously decreased on 7^{th} and 14^{th} days, but on 30^{th} day the level increased. For blank the total hardness level continuously increased on 7^{th}, 14^{th} and 30^{th} days. The maximum value of total hardness observed was 6118.3 ppm, it was observed on 30th day at blank.

4.12.4 Treatment – rock phosphate + trisodium phosphate

The variation of total hardness under the treatment of rock phosphate with trisodium phosphate at low salinity level is given in the Fig.95. For the levels of 0.1 and 0.4 ppm of phosphate-P, the total hardness level continuously increased on 7th, 14th and 30th days. For blank also the same trend was observed. For the level of 0.2 ppm of phosphate-P , the observed value of total hardness on 7th day was similar to that on first day, on 14th and 30th days the total hardness level continuously increased. The maximum value of total hardness observed was 2851.75 ppm it was observed on 30th day under the treatment level of 0.1 ppm of phosphate -P.

The variation of total hardness under the treatment of rock phosphate with trisodium phosphate at high salinity level is given in the Fig.96. For the level of 0.1 ppm of phosphate-P, an increased and similar values of total hardness was observed on 7th and 14th days , 0.2 ppm also followed the same trend. For the level of 0.4 ppm of phosphate-P, the total hardness level continuously increased on 7th, 14th and 30th days. Blank also followed the same trend. The maximum value of total hardness observed was 6118.3 ppm, it was observed on 30th day at blank

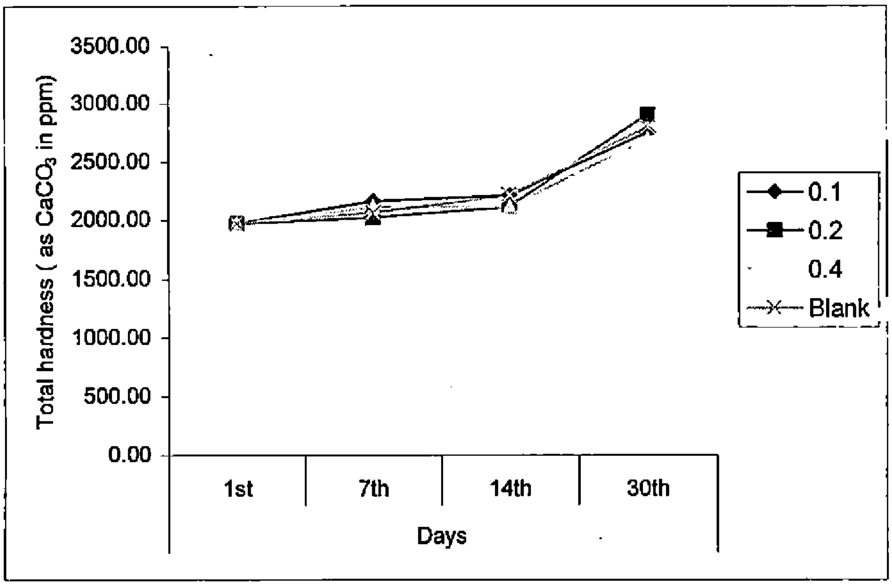

Fig.89 Variation of total hardness under the treatment of single super phosphate at low salinity level

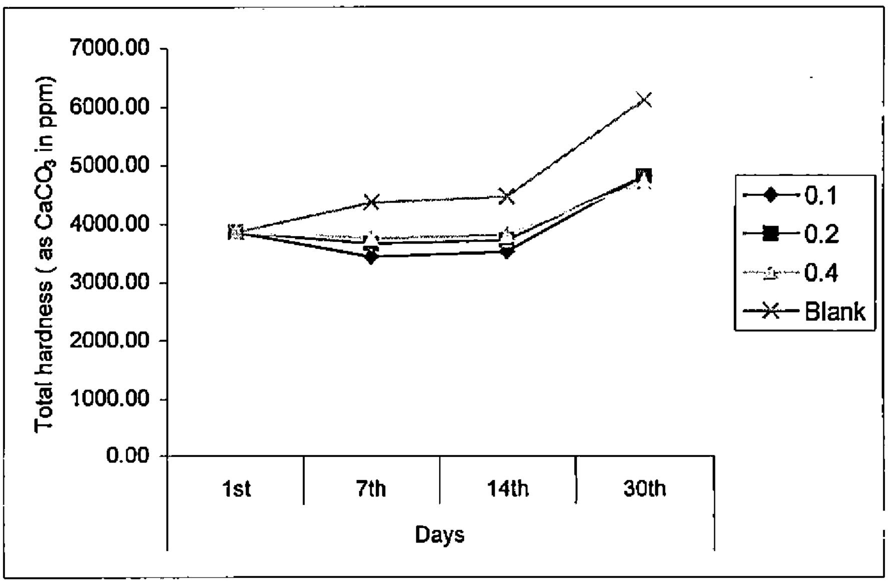

Fig.90 Variation of total hardness under the treatment of single phosphate at high salinity level

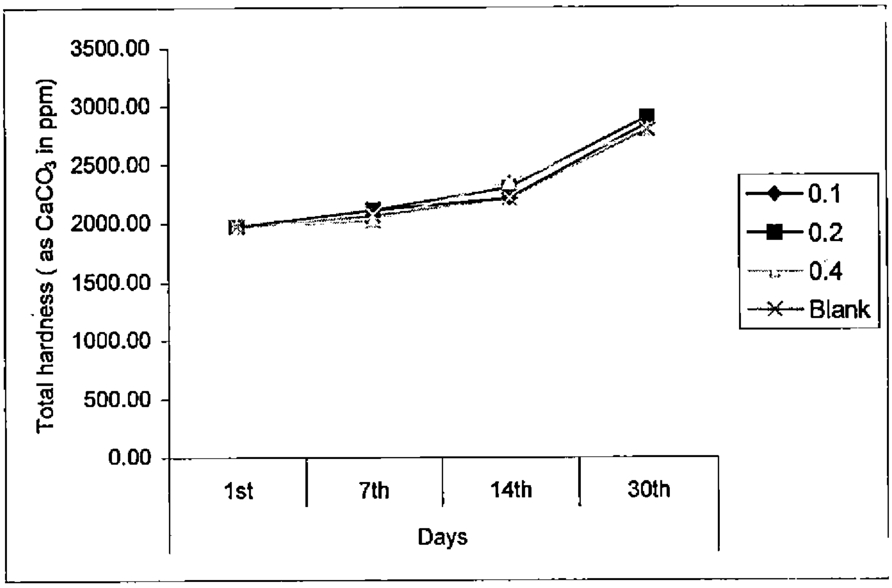

Fig.91 Variation of total hardness under the treatment of rock phosphate at low salinity level

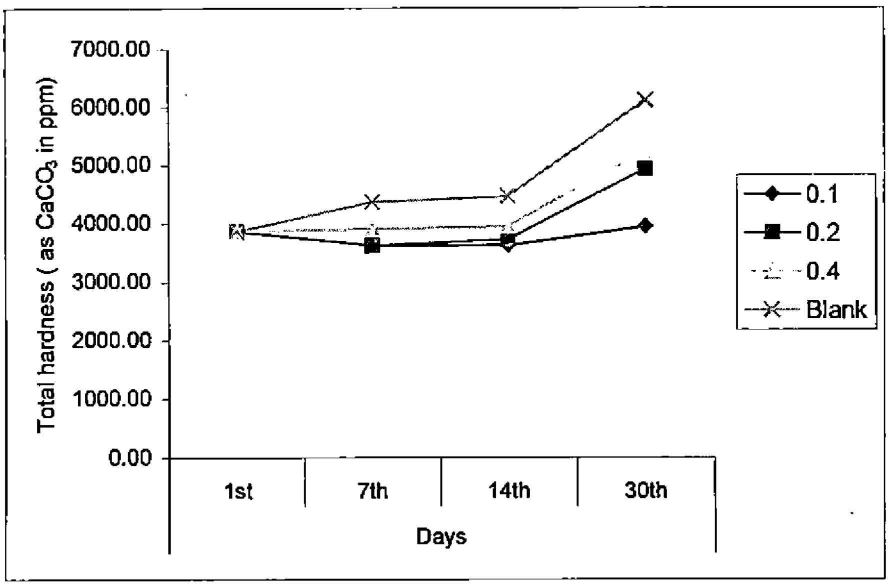

Fig.92 Variation of total hardness under the treatment of rock phosphate at high salinity level

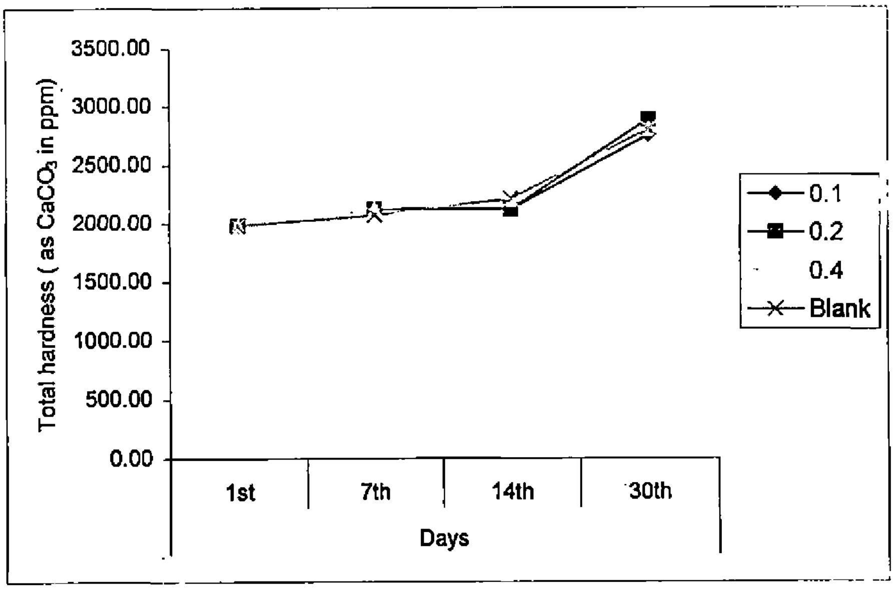

Fig.93 Variation of total hardness under the treatment of single super phosphate + trisodium phosphate at low salinity level

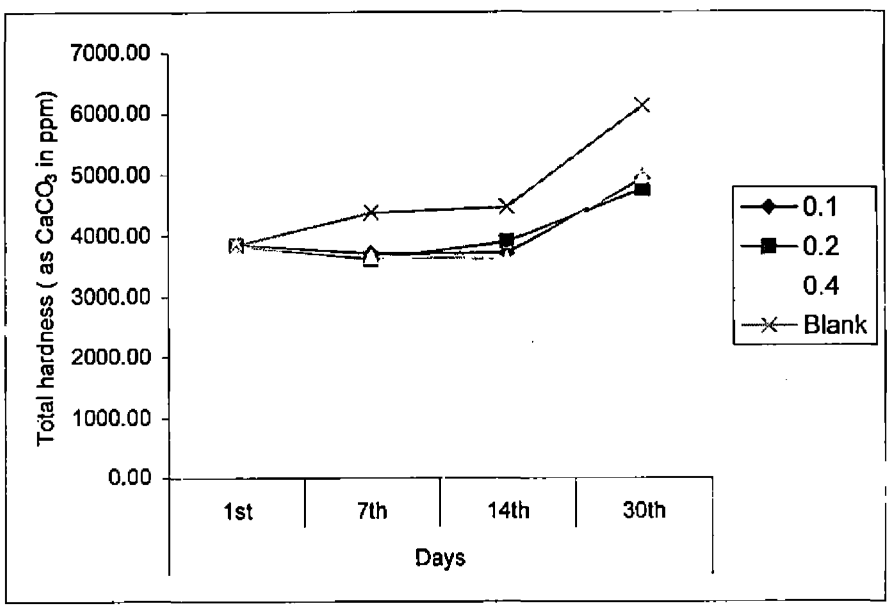

Fig.94 Variation of total hardness under the treatment of single super phosphate + trisodium phosphate at high salinity level

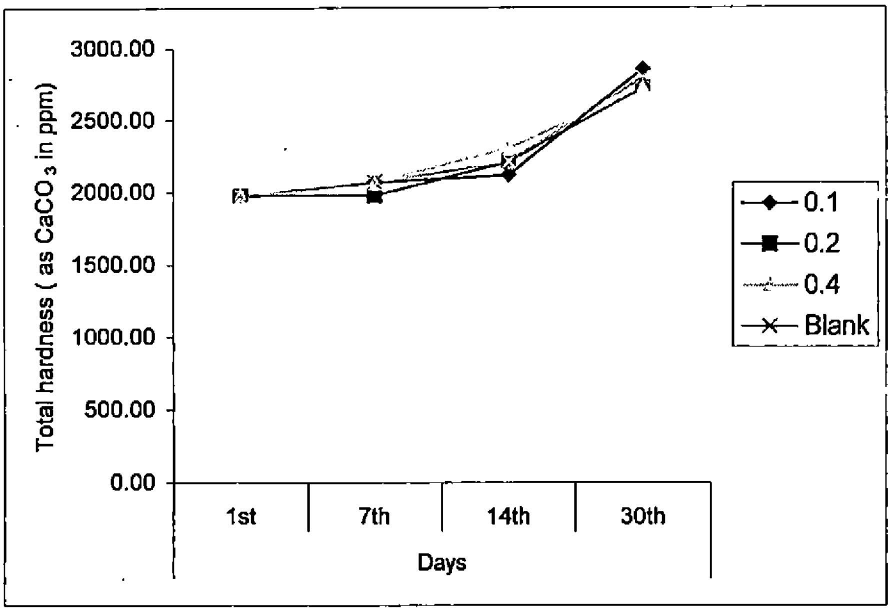

Fig.95 Variation of total hardness under the treatment of rock phosphate + trisodium phosphate at low salinity level

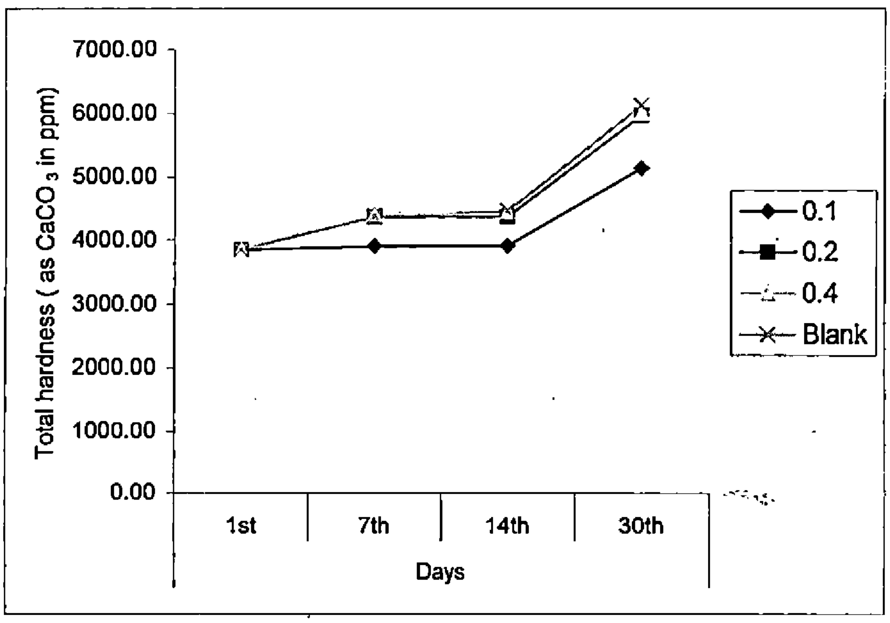

Fig.96 Variation of total hardness under the treatment of rock phosphate + trisodium phosphate at high salinity level

4.13 Changes in the calcium levels

Calcium is essential for all planktonic organisms being so important cell wall constituent. Calcium improves the texture of soil and helps in the release of phosphorus in to pond water, which remain bound in soil, unavailable for pond productivity (Reddy,1997).Chattopadhyay and Ghosh (1976) found that calcium form insoluble calcium phosphate compounds causing a decrease in the amount of water soluble phosphorus. In the present study calcium was estimated in all the tanks on 1^{st} ,7^{th} ,14^{th} and 30^{th} days.

4.13.1 Treatment – single super phosphate

The variation of calcium levels under the treatment of single super phosphate at low salinity level is given in the Fig.97. Excluding the treatment dose of 0.2 ppm, all treatment doses and blank followed the same trend of increased values of calcium on 7^{th}, 14^{th} and 30^{th} days. For the treatment dose 0.2 ppm, the calcium level increased on 7^{th} day, decreased on 14^{th} day and then again increased on 30^{th} day. The maximum value of calcium observed was 396 ppm, it was observed on 30^{th} day in blank.

The variation of calcium levels under the treatment of single superphosphate at high salinity level is given in the Fig.98. All the treatment levels and blank followed the general trend of continuously increased values on 7^{th}, 14^{th} and 30^{th} days. The maximum value of calcium observed was 780 ppm, it was observed on 30^{th} day in blank.

4.13.2 Treatment – rock phosphate

The variation of calcium levels under the treatment of rock phosphate at low salinity level is given in the Fig.99. All the treatment levels and blank followed the general trend of continuously increased values on 7^{th}, 14^{th} and 30^{th} days. The maximum value of calcium observed was 396 ppm, it was observed on 30^{th} day in blank.

The variation of calcium levels under the treatment of rock phosphate at high salinity level is given in the Fig.100. All the treatment levels and blank followed the general trend of continuously increased values on 7^{th}, 14^{th} and 30^{th}

days. The maximum value of calcium observed was 783 ppm, it was observed on 30th day under the treatment level of 0.4 ppm of phosphate- P

4.13.3 Treatment – single superphosphate + trisodium phosphate

The variation of calcium levels under the treatment of single super phosphate with trisodium phosphate at low salinity level is given in the Fig.101. All the treatment levels and blank followed the general trend of continuously increased values on 7th, 14th and 30th days. The maximum value of calcium observed was 396 ppm, it was observed on 30th day in blank.

The variation of calcium levels under the treatment of single super phosphate with trisodium phosphate at high salinity level is given in the Fig.102. All the treatment levels and blank followed the general trend of continuously increased values on 7th, 14th and 30th days. The maximum value of calcium observed was 780 ppm, it was observed on 30th day in blank.

4.13.4 Treatment – rockphosphate + trisodium phosphate

The variation of calcium levels under the treatment of rock phosphate with trisodium phosphate at low salinity level is given in the Fig.103. All the treatment levels and blank followed the general trend of continuously increased values on 7th, 14th and 30th days. The maximum value of calcium observed was 396 ppm, it was observed on 30th day in blank.

The variation of calcium levels under the treatment of rock phosphate with trisodium phosphate at high salinity level is given in the Fig.104. All the treatment levels and blank followed the general trend of continuously increased values on 7th, 14th and 30th days. The maximum value of calcium observed was 791 ppm, it was observed on 30th day under the treatment level of 0.1 ppm of phosphate P.

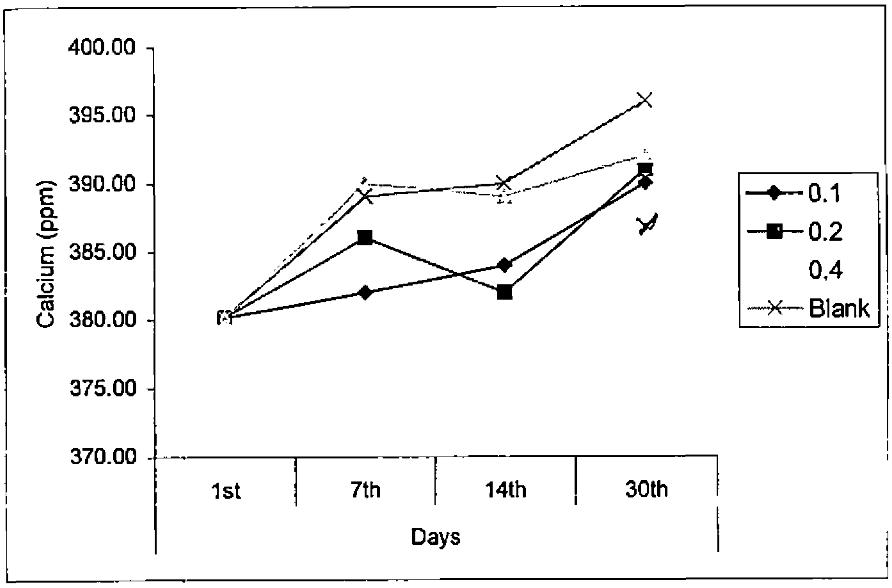

Fig.97 Variation of calcium under the treatment of single super phosphate at low salinity

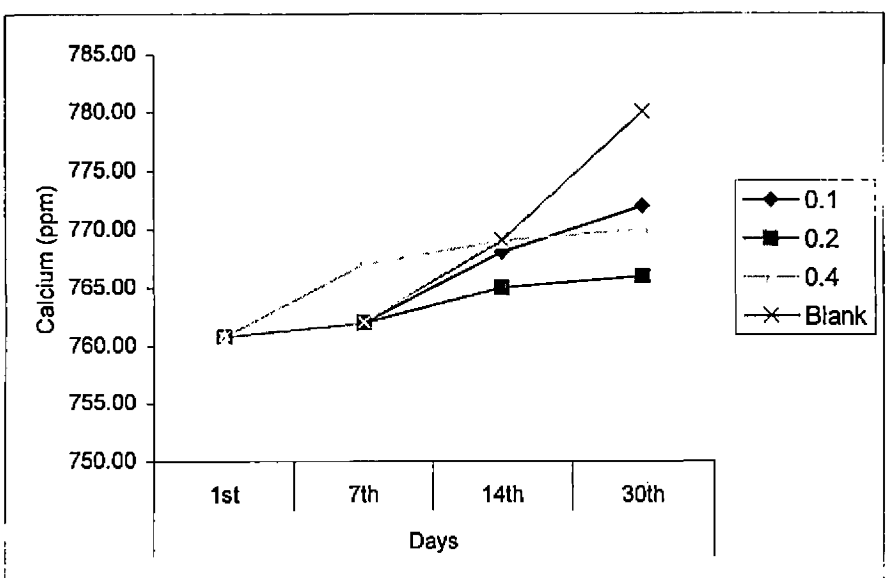

Fig.98 Variation of calcium under the treatment of single super phosphate at high salinity level

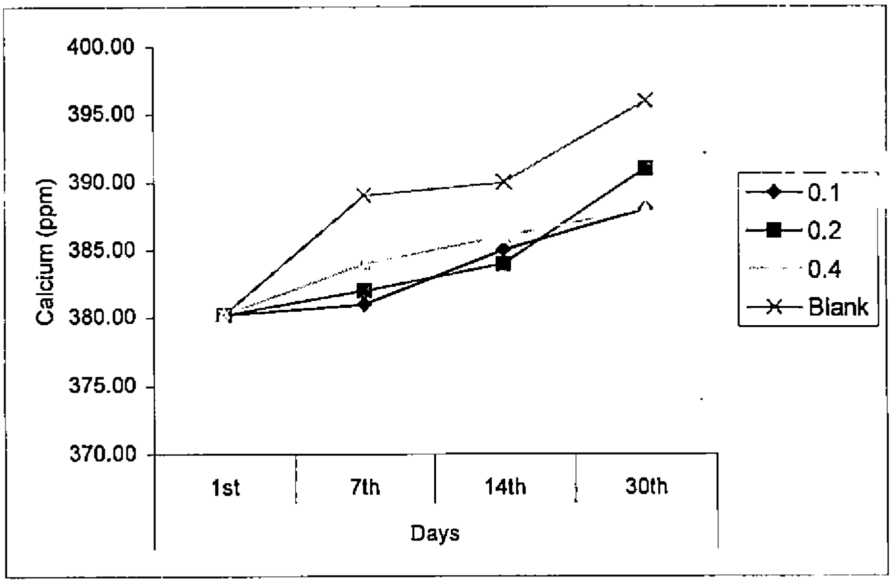

Fig.99 Variation of calcium under the treatment of rock phosphate at low salinity level

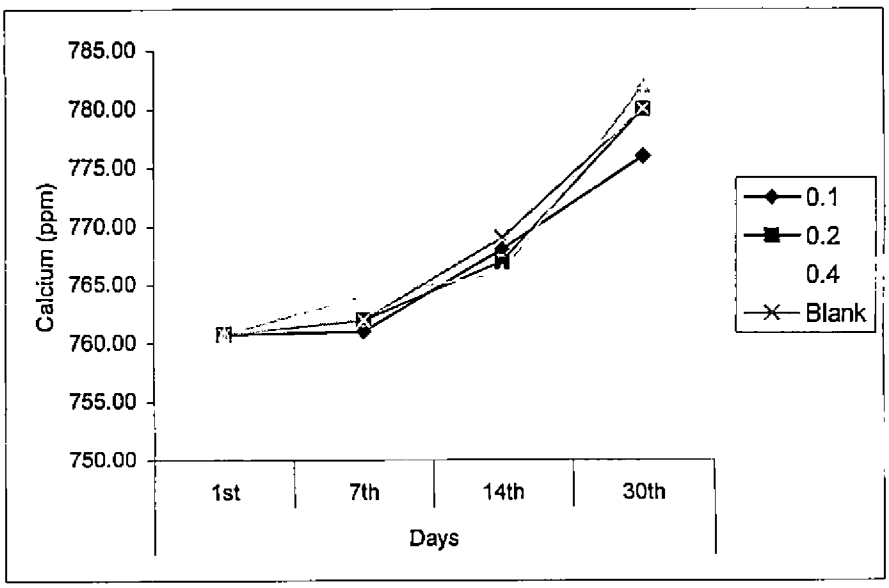

Fig.100 Variation of calcium under the treatment of rock phosphate at high salinity level

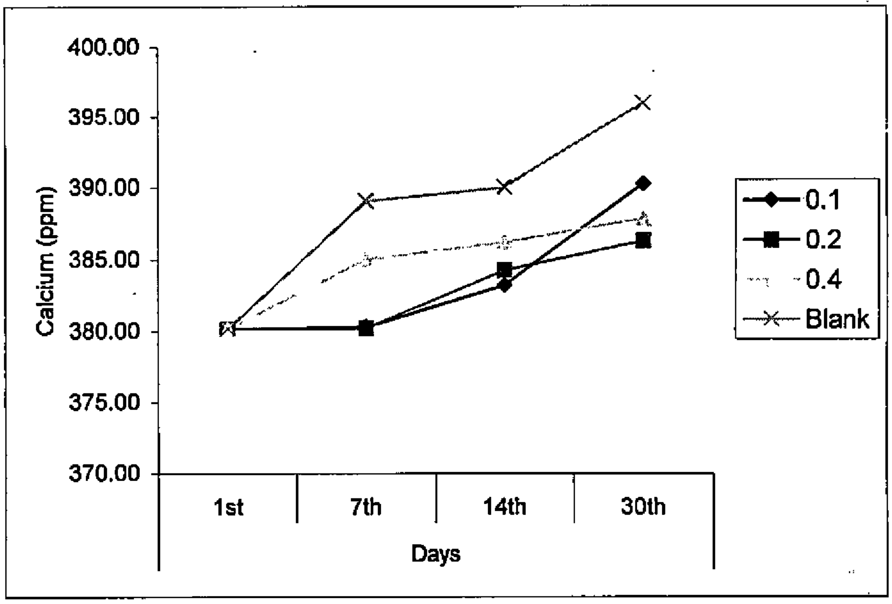

Fig.101 Variation of calcium under the treatment of single super phosphate + trisodium phosphate at low salinity level

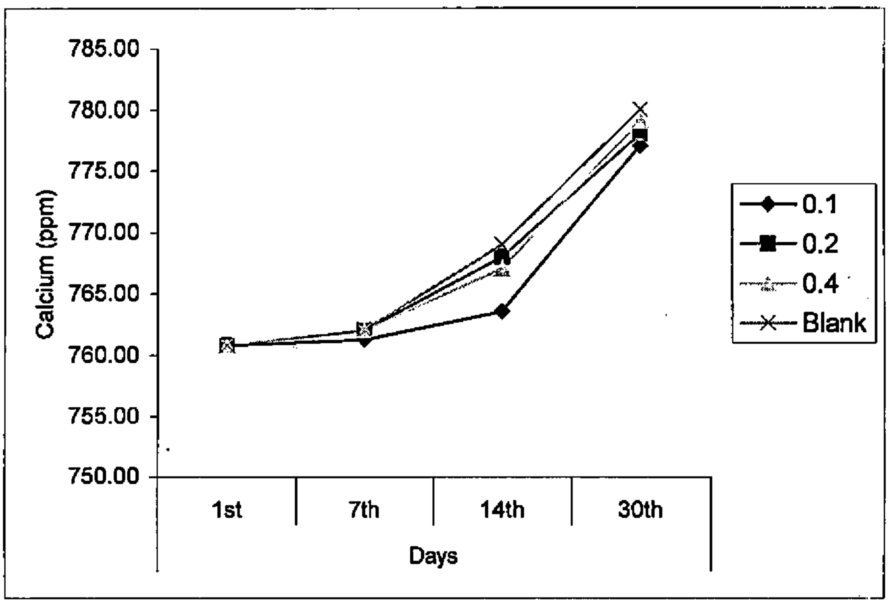

Fig.102 Variation of calcium under the treatment of single super phosphate + trisodium phosphate at high salinity level

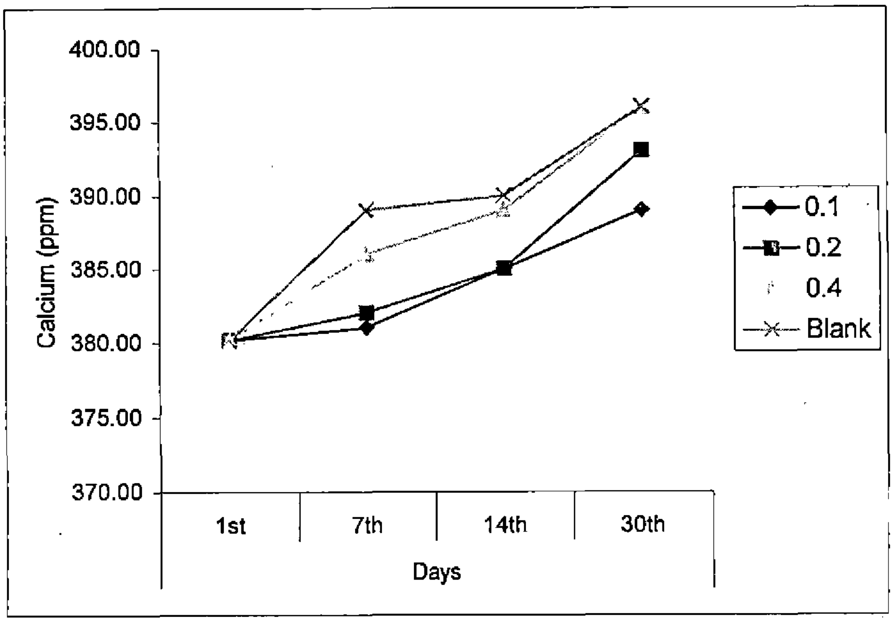

Fig.103 Variation of calcium under the treatment of rock phosphate + trisodium phosphate at low salinity level

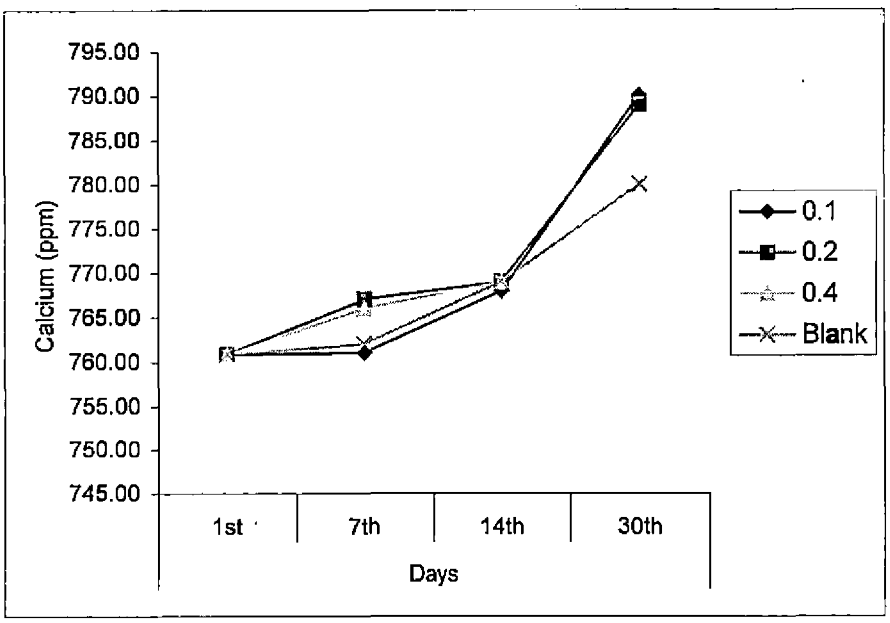

Fig.104 Variation of calcium under the treatment of rock phosphate + trisodium phosphate at high salinity level

Discussion

5. DISCUSSION

5.1 Changes in available phosphate

5.1.1 Treatment – single superphosphate

In the treatment with single super phosphate in concentrations 0.1 ppm, 0.2 ppm and 0.4 ppm of phosphate-P, it was observed that there was a general increase in available phosphorus content (Fig.1, 2). This increase was observed up to 7th day in the case of low saline medium, then its concentration was found to drop to almost nil as observed on 30th day. This was true in all the concentrations. Highest concentration recorded was 0.292 ppm in the case of low saline medium. It was also seen that initially there was a slight decrease followed by an increase in the concentration of available phosphorus in all concentrations. However, there was general increase in the concentration of available phosphate observed after the application of fertilizers. This could be due to the release of phosphorus from the added fertilizer. Boyd *et al.* (1981) found that the concentration of available phosphate increased following the application of phosphatic fertilizers in culture ponds. In the case of high saline water, the release was a little delayed, the reason for this can be assigned to the fertilizer-salt interaction. The initial concentration of available phosphate in the high saline medium was little higher, this can be due to higher content of mineral phosphate in sea water. In both media, highest available phosphorus was recorded in the treatment with 0.4 ppm. So it could be observed that greater the dose of fertilizer, the more the quantity of available phosphorus in the media. Boyd *et al* (1981) conducted a study on the effect of three phosphatic fertilizers like triple superphosphate, diammonium phosphate and ammonium polyphosphate on phytoplankton densities, and through their study they found that the concentration of available phosphorus (inorganic phosphorus) increased following the application of phosphatic fertilizers in their study ponds.

5.1.2 . Treatment – rock phosphate

In the experiment using a natural mineral phosphatic fertilizer rock phosphate, the general trend of the release of available phosphorus into the medium was found to be increasing due to application of fertilizer (Fig.3,4). In both the salinities almost similar trend was observed. This similarity could be observed in dose wise and day wise patterns. However, there was an increase of phosphorus from 14th day to 30th day in high saline media at a treatment dose of 0.1 ppm of phosphate-P. This could e due to the organic decay and release of phosphorus. Boyd and Tucker (1998) found that ,many forms of organic phosphorus are readily hydrolyzed by extra cellular phosphatase enzymes produced by phytoplankton and heterotrophic microorganisms, the orthophosphate thus released by enzymatic hydrolysis is then available for uptake by the phytoplankton. This may happen in certain individual cases. In the rock phosphate treatment, highest available phosphate content was observed on 7th day in both the salinity mediums, but in the case of super phosphate in high saline media, release of available phosphorus was found highest on 14th day. This could be an indication that the natural rock phosphate was not affected by the salt interaction in the release of available phosphorus. Again, in the case of rock phosphate, the release of available phosphate was found to be higher indicating the freedom from salt effect.

5.1.3 Treatment- single super phosphate + tri sodium phosphate

In the study, using the combination of single super phosphate and trisodium phosphate, the release of available phophorus was found to be comparatively high compared to the treatment with single superphosphate alone and also rock phosphate alone (Fig.5,6). This could be substantiated by the high solubility of trisodium phosphate ,Brown (1973). Further, the trisodium phosphate was found not affected by the salts present in the medium as supported by Atkinson and Mavituna (1991). This fact was evident in high available phosphorus values in both the saline mediums. As in the case of single super phosphate treatment, the highest value was observed on 7th day.

However, in this case the release pattern was repeated in high saline medium also, which could be again due to freedom from salt effect on trisodium phosphate. In high saline medium, slight increase of available phosphorus after the 14^{th} day was observed in all concentrations. It could be argued that either the absorption of plankton was retarded or the release of phosphorus from the medium happened. Grasshoff et al (1983) found that hydrolysis of polyphosphate will results in the production of pure orthophosphate, which is readily utilized by phytoplankton. Rajagopalsamy *et al.* (1997) confirmed the quantitative removal of soluble in- organic phosphate through phytoplankton assimilation. In all the cases, higher dose of fertilizer caused release of higher quantity of available phosphorus. However in the case of low saline medium, decline of higher available phosphorus was slow from 7^{th} day to 14^{th} day for treatment with 0.4 ppm. In all other cases, the decline was sharp from 7^{th} to 14^{th} day. The above change could be due to the environmental effect on the absorption of available phosphorus by plankton. Boyd and Pillai (1984) found that phytoplankton can quickly absorb orthophosphate from water; in fact plankton can absorb 50% or more of phosphate added in a normal fertilizer application within 24 hrs.

5.1.4 Treatment – rock phosphate + tri sodium phosphate

In the treatment with a combination of rock phosphate and trisodium phosphate, the trend of releasing available phosphorus was found to be in the same pattern in both the salinity media (Fig.7,8). The available phosphorus was increased from 1^{st} day to 7^{th} day followed by a sharp decline from 7^{th} day to 14^{th} day. Here also there was a slight increase in the available phosphorus from 14^{th} day to 30^{th} day in high saline medium. This was also observed in the treatment with rock phosphate alone, this could be due to either release of available phosphorus by decay of organic matter or release from the salt mineral or by both the process. Martin (1970) found that dissolved inorganic phosphorous can be produced by the decomposition of organic detritus.

In all the four sets of experiments, it could be observed that the release of available phosphorus was increased when fertilizer was added. The release of available phosphorus was found to be in accordance with the dose. So the addition of fertilizer had a positive effect. Saha and Chatterjee (1979) did experiments on the availability of phosphate from different phosphatic fertilizers. Under their study they found that the availability of phosphate level increased considerably following the application of phosphatic fertilizers. The maximum increase of available phosphorus was from 1st day to 7th day, which could be the effect of addition of fertilizers. There was a sharp decline of available phosphorus from the 7th day to 14th day except in a few cases, it could be a clear indication of absorption of phosphorus by plankton. Sorokin (1983) had done experiments on the rate of inorganic phosphate uptake by phytoplankton and established a close positive correlation between phosphate consumption and primary production. The absorption of available phosphorus by phytoplankton was also observed by Jhingran (1991). This observation could lead to an inference that the efficiency of phosphatic fertilizer application could be started from 7th day in terms of productivity. This idea was found to reflect in the changes in the concentration of chlorophyll during the corresponding time. The trend of changes of available phosphorus in low saline and high saline media was found to be almost similar except in a few cases. However, in high saline medium, there was a slight increase of available phosphorus from 14th day to 30th day, which could be substantiated by the effect of decay of organic matter and release of available phosphorus from salt. From the result, it could be observed that release of available phosphorus was highest in the treatment which the combination of rock phosphate with trisodium phosphate followed by slight low values in the case of treatment with single super phosphate and trisodium phosphate. Comparatively low values in the treatment with rock phosphate alone followed by the lowest value for single super phosphate alone. It was also concluded from statistical analysis using ANOVA technique that salinity of the medium, type of fertilizer and their levels were found to have significant effect on the observed available phosphorus levels .

5.2 Changes in Chlorophyll

5.2.1. Treatment – single superphosphate

In the experiment with treatment of single superphosphate, it was observed that, the chlorophyll content had increased substantially in all concentrations (Fig.49,50). This was true in both the salinity media. In the treatment with higher dose of fertilizer, higher amount of chlorophyll was observed, this trend was seen in the concentration of available phosphorus, so it could be theorized that higher amount of fertilizer could release higher amount of phosphorus, which in turn could promote greater productivity. It was in general agreement with the expected result of fertilization. Banerjea (1967) found that in laboratory and field experiments, the plankton concentration of the water could be increased considerably by supplementing the available phosphorus. Vrede *et al.* (1999) reported instances of stimulating the phytoplankton growth by the application of phosphorus alone. In the high saline medium, however, the productivity was a little high compared to low saline medium. These higher values were observed in the initial and final observations, so it could be due to the mineral supplements from the high saline medium, which could support the growth of plankton.

5.2.2 Treatment – rockphosphate

In the treatment with rock phosphate almost same trend with almost same values of chlorophylls could be seen. The fertilizing effect of rock phosphate is at par with single superphosphate. Though the available phosphorus content in the rock phosphate treatment was found to be more, the productivity levels in both the treatments were almost same, if not a little higher in he case of single superphosphate treatment. The release of available phosphorus could have been affected by salt in the case of single superphosphate, but supply according to the requirement of plankton could be same, this can be due to the solubility factor of single superphosphate.

5.2.3 Treatment – single superphospahte + trisodium phosphate

It was observed from the data regarding treatment with single superphate and tridoum phosphate that the productivity in terms of chlorophyll content was the highest. Boyd *et al* (1981) conducted a study on the effect of three phosphatic fertilizers like triple superphosphate, diammonium phosphate and ammonium polyphosphate on phytoplankton densities, and through their study they found that the concentration of available phosphorus (inorganic phosphorus) increased following the application of phosphatic fertilizers in their study ponds. The trisodium phosphate is a phosphorus containing chemical which is highly soluble in water Atkinson and Mavituna (1991). The solubility could not be affected normally by the presence of other salts to a substantial level. These properties of the additive, trisodium phosphate, could be the main reason for the release of available phosphorus to greater amount and production of chlorophyll by plankton. In the case of saline medium, the productivity was found to be a little high, which could be due to the supplement of minerals.

5.2.4 Treatment – rockphsophate + tridoium phosphate

Treatment with rock phosphate and trisodium phosphate also found to be promissive in terms of primary production. In this treatment, effect of trisoidum phosphate was found to be prominent Brown (1973). This could be observed on comparison of production in treatment with rock phosphate alone especially in low salinity. High salinity in the medium supported by the growth of plankton, presumably due to the availability of certain additional essential nutrients from the saline water.

It was observed from the four sets of experiments that concentration of chlorophyll was increased with increase of available phosphorus. It could be also seen that productivity could be increased by supplementing phosphatic fertilizers in saline waters. Reddy (1997) found that presence of high concentration phosphates in water will accelerate plankton growth. Rajagopalsamy *et al.* (1997) through their experiments found that there was a quantitative removal of phosphorus in the form of orthophosphate through phytoplankton assimilation. Padmavathi *et al.* (1997) have described phosphorus as an indispensable nutrient which is present in lesser concentrations in pond waters to promote abundant phytoplankton growth. Sarkar (1991) studied the effect of super phosphate on fish and aquatic ecosystem and found that, the concentration of phytoplankton and zooplankton increased considerably by super phosphate addition. During studies by Banerjee and Roychoudhury (1966) in Chilka Lake it was found that when the phytoplankton concentration is increasing, the phosphate value showed a corresponding decline in concentration substantiating the statement by Khan and Siddiqui (1974). In high saline water, fertilizing effect was found to be little more. It was found that the fertilizer additive could promote the primary production, evidently due to its higher solubility and availability of phosphorus.

Chemical quality parameters of the test media were observed regularly on 1^{st} , 7^{th}, 14^{th} and 30^{th} day. It was observed that all the parameters were within the limits for the purpose of aquaculture as observed by several authors (Prakash,1997; Reddy,1997; Boyd and Tucker, 1998; Pillay, 1990; Lawson, 1995; New and Singholka, 1985; Huet, 1972; Stumm and Morgan, 1970) described the quality factors affecting the availability of phosphorus. According to them, iron, aluminium and calcium are the main ions that fix the phosphorus. Krom and Berner (1980) found that high content of iron compounds in the water results in the adsorption of available phosphate by iron compounds. In the experimental medium iron content was found low which could not have affected the phosphate availability. In the present study also concentration of iron was not high. A slight increase in the calcium noted in the observation could be due to accumulation of that ion on subsequent addition of saline water for compensating the volume decreased during the experiment.

The calcium, aluminum also could be at par with the salinity which might not have affected the availability of phosphorus. pH is another factor that could block the release of phosphorus, here the pH range was favorable for phosphate availability. The importance of pH in the precipitation of iron from water was shown by laboratory experiments by Fukai and Huynh Ngoe(1988). In their experiment iron was found to lost from solution, with approximately 90% of the added iron being removed at pH 7. In an estuary where the pH is approximately 8, the efficiency of removal of phosphate will be greater in fresh than in the saline part of the estuary (Liss, 1976). Prakash (1997) found that in estuarine backwaters, the pH can range from 7 to 8.7. Burton (1976) found that, the water pH for phosphate adsorption shows a broad maximum in the range of pH from 3 to 9. Here the water pH was always above 7 (Fig.57-64). This pH normally does not affect the availability of phosphorus. Changes in the dissolved oxygen were found to be in accordance with production pattern i.e with the increase of production, higher amount of oxygen was observed (Fig.65-72). Other parameters like total alkalinity, hardness, nitrite, nitrate were also found to be sufficient for normal production (Prakash,1997; Reddy,1997; Boyd and Tucker, 1998; Pillay, 1990; Lawson, 1995; New and Singholka, 1985; Huet, 1972; Stumm and Morgan, 1970). So it could be concluded that the chemical parameters did not found to affect the influence of phosphorus in promoting the productivity.

It was also concluded from statistical analysis using ANOVA technique that, the treatments with the fertilizer additive trisodiumphosphate have significant effect on the observed values of chlorophyll on 30^{th} day. It was also concluded from statistical analysis that, the observed values of chlorophyll on 30^{th} was significantly affected individually by salinity, type of fertilizers and their levels. The interaction between salinity and type of fertilizer, type of fertilizer and their levels and salinity and different fertilizer levels were also found to be significant

Summary

6.SUMMARY

1. The present study was carried out to find out the effect of phosphatic fertilizer compounds on aquatic primary production in saline water. The main objective of the study was to identify the most effective phosphatic fertilizer and its dose suitable for saline water fish farms. Another objective was to find out the effect of trisodium phosphate as an additive to increase the available phosphorus and aquatic primary production.

2. In the experiment a synthetic phosphatic fertilizer namely single superphosphate, a natural phosphatic fertilizer namely rock phosphate, a combination of single superphosphate with trisodium phosphate and a combination of rockphosphate with trisodium phosphate were tested for their fertilizer effect. Commercial grade of trisodium phosphate was used as additive in combination with single superphosphate and rock phosphate in 1:1 proportion in both cases.

3. Experiments were done in brackish water with two salinity levels of approximately 10ppt and 20ppt, so as to assess the effect of each type fertilizers and their combinations in different saline waters.

4. The four types of fertilizer materials namely i) single superphosphate ii) rock phosphate iii) single superphosphate with trisodium phosphate iv) rock phosphate with trisodiumphosphate were tested in the experiment in three doses namely 0.1 ppm phosphate-P, 0.2 ppm phosphate –P and 0.4 ppm phosphate –P. A set of controls were also run in both the saline media.

5. Inoculums of brackish water plankton were seeded in all the tanks in equal amount. The tanks were kept exposed to sunlight for 30 days. The experiment was statistically designed using Completely Randomized Design with two replications.

6. Water quality parameters viz, alkalinity, hardness, dissolved oxygen, pH, carbon dioxide, iron, calcium, reactive-P, nitrite, nitrate, silicate and total phosphorus were assessed on 1^{st} , 7^{th}, 14^{th} and 30^{th} days. Chlorophyll was determined on 1^{st} day and 30^{th} day only.

7. It could be observed from the experiment that, the quantity, type and chemical nature of the fertilizer could influence the concentration of available phosphorus and the production of Chlorophyll. The fertilizer additive trisodiumphosphate would influence the concentration of available phosphorus and also the primary productivity.

8. From the present study it could be concluded that, fertilizer combination of single super phosphate with trisodium phosphate additive at a concentration of 0.4 ppm of phosphate-P was the most effective in releasing the inorganic phosphate and increasing the primary productivity in brackish water compared to other materials.

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EFFECT OF PHOSPHATIC FERTILIZER COMPOUNDS ON AQUATIC PRIMARY PRODUCTION IN SALINE WATER

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ABSTRACT OF THE THESIS

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ABSTRACT

Fish production in farms largely depends on the primary productivity in the water bodies. Among many factors, plant nutrient levels and their availability in absorbable forms for the plankton is the most important one contributing to primary production. The plant nutrient element, phosphorus often found to limit the production, mainly due to the behavior of phosphorus compounds to remain in unavailable form in aquatic environment. Hence it becomes imperative to supplement phosphorus in suitable chemical form to achieve better production. While the dosage is also important, the salinity of water bodies has an interactive effect. Thus species of compounds in phosphatic fertilizer is vital.

In the present study, two types of phosphatic fertilizers and combination of these fertilizers with additives were tested for their effect on aquatic primary production. Synthetic fertilizer namely single superphosphate and natural phosphatic fertilizer namely rock phosphate were selected for study. Commercial grade trisodium phosphate was used as additive in combination with single superphosphate and rockphosphate in 1:1 ratio with respect to phosphate-P.

All the above four fertilizer materials were tested in brackishwater having two salinity levels, a low salinity level of approximately 10 ppt and a high salinity level of approximately 20 ppt. Each fertilizer was added in three different doses , ie, 0.1ppm, 0.2 ppm and 0.4 ppm of phosphate-P. A set of control with two salinity level of water and without adding fertilizer were also run. All the experiments were done in duplicate, in accordance with statistically designed 2×4×4 Factorial Completely Randomized Design. The experiments were conducted in wide mouth polythene drums having 25 litre capacity using 20 liters of water. The experiment was set up in a protected, undisturbed, elevated place and kept exposed to sun light for 30 days. Volume loss due to evaporation was compensated by adding appropriate amount of water having corresponding salinity.

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Water samples were drawn on 1st day (before the addition of fertilizer), 7th, 14th and 30th days and analysed for available phosphate, total phosphate, silicate, nitrite, nitrate, iron, water pH, dissolved oxygen, carbon dioxide, total alkalinity, total hardness and calcium. Productivity was assessed on 1st day and 30th day by estimating chlorophyll. The results were statistically analysed with ANOVA technique.

In the experiment, maximum productivity in terms of chlorophyll (14.6mg/m^3) was found under the treatment with single super phosphate along with additive trisodium phosphate when applied at a dose of 0.4 ppm of phosphate-P in the high saline media. For the same type of treatment in low salinity level, a little reduced value of productivity was observed (chloropyll =13.9 mg/m^3). The next effective treatment was rock phosphate with trisodium phosphate at a concentration of 0.4 ppm of phosphate-P, here a chlorophyll concentration of 13.6mg/m^3 and 12.6 mg/m^3 were obtained in high and low salinities respectively. The minimum productivity levels were observed in treatments with rock phosphate alone in all concentrations, compared to other treatments.

It could be concluded from the experiments the following i) single super phosphate with a combination of trisodium phosphate was most effective compared to rock phosphate with trisodium phosphate, which could be due to the greater solubility of single super phosphate ii) single super phosphate was found to be more effective than rock phosphate, which could be due to the grater solubility as already explained. iii) the concentration level of 0.4 ppm of phosphate-P was found to be the most effective in enhancing the primary production compared to the lower doses tried ie, 0.1 and 0.2 ppm. iv) along with an increase in the available phosphate from the added fertilizers there was an increase in the primary production also v) salinity was found to have some effect on production, higher the salinity grater the production. This can be due to the availability of other minerals and intrinsic factors required for the synthesis of chlorophyll and biomass.