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SEASONAL CHANGES IN PHYSICO-CHEMICAL ATTRIBUTES OF SALT AFFECTED HABITAT

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ABSTRACT

The salt affected habitat are stress habitat known for its greater pH EC values. The habitats are not fit for production of any type of crop. The paper summaries the seasonal fruction of physico-chemcial parameters of two salt affected sites. The properties fructated due to seasonal change studied in this research work. The greater fruction in the physico-chemical are indicative of the behaviour of edafic environment.

KEYWORDS : Seasonal Changes, Physical & Chemical Parameters, Salt Affected Habitat

Soil salinity (and or alkalinity) is one of the serious global problems telling upon economic utilization of land resources in arid and semi arid environments (Yadav, 1977). About l/3rd of the cultivable land under irrigation in the world is presently known to be under the influence of salinity. Salt-affected soil is spread over 900 million hectares of land over the world in such countries as India, U.S.A., U.S.S.R., Australia, Hungary, Romania, Yugoslavia, Czechoslovakia, Egypt, Pakistan, Iran, Iraq, Isreal, Turkey, China, Mexico, the Netherlands, Germany, Denmark, Italy, France, North Africa and the coastal tracts of Britain (Singh, 1980). Soil salinization caused by irrigation is reported to be responsible for the end of civilization in Mesopotamia (Yadav, 1977).

In India, an area as large as 7 million ha. is reported to be under salinity effect (Yadav, 1981). Such areas are spread over the Indo-Gangetic plains, arid and semi arid areas of Rajasthan, Gujrat and Harayana, heavy black clay soils of Deccan and coastal areas (Abrol, 1983). Such a vast expanse of salt-affected area presents a serious threat to our agriculture and calls for the development of suitable techniques for their economic utilization with regard to crop production in order to feed the alarmingly increasing rate of our human family.

Considerable amount of information is now available on the extent of the problem and several methods of reclamation have been suggested by different workers. Since the majority of the reclamation procedure is location specific, generalization of any technique is rather risky, simply because conditions differ from place to place. A critical review of the literature, however, reveals that a successful reclamation involves a package of practice suited to the type of salt-affected soils which can be broadly divided into 'Saline soils' and Alkali soils or Sodic soils' from the management point of view (Abrol, 1983). The practices will further vary according to the nature and problem of the soil, availability and quality of irrigation water, quality and depth of ground water, calcareousness and gypsum content of the soil, pervious and impervious nature of sub-soils, availability and economics of the ameliorative measures (Mehta, 1983). The methods of reclamation comprise (i) Chemical, (ii) Agro technical, (iii) Hydro technical including engineering aspects and (iv) Biological methods.

Some workers have obtained beneficial results in reclaiming alkali soils with the application of heavy doses of molasses, a bye-product in the sugar industry, Dhar and Mukherjee (1938), stated that the molasses, due to its high content of carbo-hydrate, created acidic conditions in the soil through decomposition resulting in the formation of organic acids which neutralised the alkalinity of the soil and as molasses contains 2% lime, it helps displacement of Na+ from the exchange complex. Some other industrial waste materials have also received attention. These chemical amendments are costly, not easily available and their use involves technical skill and therefore, their application in practice has been to a limited scale .

The global phenomenon of inflation and energy crisis witnessed in recent years have further aggravated the situation with respect to production as well as supply of

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chemical fertilizers. Obviously fertilizers, have become the costliest input in today's farming. Considering the wide gap between the present supply position and requirement in the agricultural sector, it seems difficult to meet full fertilizer needs of farm crops in near future, even with the increasing pace of production and supply.

The situation calls for a fresh look on the exploitation of local manurial resources including bacterial fertilizers, farmyard manures and organic matters so as to reduce absolute dependence on mineral fertilizers alone. Recycling of agricultural, domestic and suitable industrial wastes on farm soils for increasing productivity needs a serious consideration. At the same time, it would be a mistake to assume that bio-organic materials, however, effective they may be, can meet absolute manurial requirements of crops in the present intensified farming practice. They have to be viewed as a supplementary source of improvement of the fertility status of our soils) (Yadav,1981).

The use of manures and fertilizers in alkali soils is important as these soils are generally deficient in available plant nutrients like, nitrogen, Ca^{++}, Zn^{++} etc. and are often poor in organic matter (Dargan and Chhillar, 1980; Yadav, 1981).

The beneficial effect of the application of organic matter and FYM to saline-alkali soils for reclamation purpose have been observed by several workers (Kanwar, 1962; Mendiratta et al., 1972; Swarup, 1980; Singh et al., 1980).

Agronomic value of organic matter in the form of farmyard manures and green manures is well known to the cultivator from historic times, however, with the advent of quick-acting inorganic manures, the use of organic manures has become less popular. The constant use of organic manures plays an unquestionable role in stabilizing productivity of the soils not only, by the release of their constituent inorganic nutrients but also playing an important role in the improvement of the physical condition of the soil. Associated with the advantage is the fact that there is a linear relationship between the amount of organic matter added to the soil and its bio-chemical activity which is directly related to the productivity of the soil (Bhumbla, 1980).

Singh, (1950) reported that the blue-green algae is capable of solubilizing calcareous deposits and thus Ca^{++} liberated in the soluble form from the native $CaCO_3$ helps in reducing exchangeable Na^+ in the soil complex. User soils can be reclaimed successfully through the blue-green algae for the subsequent cultivation of crops like paddy and sugarcane. As a result of abundant algal growth the status of organic matter and nitrogen is increased which helps in binding the soil particles and in improving soil permeability, aeration and other physical properties. Greater increase in soil physico-chemical properties as well as in crop yields have been found under field conditions of the growth of blue-green algae (Kaushik et al., 1981).

Plant growth imparts ameliorative effect by loosening the soil and improving its permeability to water through the action of the root system, by adding organic matter through the leaf litter and root residue, by producing carbonic acid through root activity and decay of organic material by stimulating microbial activity and by moderating the effects of climate. Under these conditions Ca^{++} of the native $CaCO_3$ is released in soluble form which gradually replaces sodium in the exchange complex of the saline alkali soils (Yadav, 1981; Petrosyan, 1984). A decrease in the value of pH and soluble salt-content and an increase in the status of organic matter and nitrogen content of the soil under Prosopis specijera have been reported to occur in upper 15 cm layer of soil (Yadav and Singh, 1970; Choudhri et al., 1979; Yadav, 1980). The work of Vadiunina (1964) shows that the tree growth improves under permeability of the solonetz soil substantially and reduces the salt content as a result of leaching.

Inducement of growth of grasses tolerant to alkali has been reported to be beneficial in reclaiming the saline alkali soils (Fuller et al.,1982). Structural changes of soil under grasses is attributed to the dissolving action of carbonic acid produced by the root system on $CaCO_3$ of a calcareous alkali soils, addition of large amount of organic matter to soil and the action of the plant roots in imparting shape and pore spaces to soil aggregates.

The soil inhabiting fungi are known to play a significant role in soil amendment through litter decomposition, mineralization of nutrients and water conservation .Fungi are abundantly found in alkaline soils and are known to play a good part in the microbiological activity of such soil systems . During decomposition of organic materials, soil microbes release a variety of cementing substances of polysaccharide nature (Murayama, 1984) which, when dries, act as a strong binding agent holding particles together in water stable aggregates (Chanay and Swift, 1984).

The relationship between plant roots, organic matter and micro-organisms are clarified by some experiments with calcareous soils in New Mexico where soil aggregation never occurred except in the presence of living microbes in which fungi had the principal role.

In view of what has been stated above, it is evident that the ultimate aim of these studies is reclamation of these habitats, which because of occurrence of an excessive amount of water soluble salts cannot be used as such by farmers for the production of food. In the present study, emphasis has been given on the investigation of the relationship between the abiotic factors and the organisms living in the edaphic environment together with their relationship with the cover crop.: Cynodon dactylon Phyla nodiflora, Pluchea lanceolata and Sporobolus diander. The cover crop is grass dominated, with a few shrubs and forbs growing here and there. In the present study, the following species have been considered But water being a limiting factor in our subcontinent with 3/4th of our cultivated area lacking irrigation facilities, any effort in bringing a solution of a permanent nature to this acute problem proves futile unless substantiated by an improvement of the moisture retaining capacity of the soil. Thus, assessment of relationship between the cover crop and the factors stimulating root growth of plants, nutrient dynamics and improvement in the physico-chemical conditions of the edaphic system have been the principal points of attention. The study has revealed information which may prove to be useful in the reclamation of these otherwise useless habitats.

After surveying the several localities under salinity effect in Varanasi and nearby areas, two sites were selected for the present study. Both sites were situated within a hundred kilometer radius of the Banaras Hindu University Campus.

MATERIALS AND METHODS

The composite air dried samples collected from the sites. The standard medhtods were used for analysing the physico-chemical parameters of the edaphic environment. The research work conducted in the laboratory of ecology, Department of Botany, Banaras Hindu University, Varanasi (U.P.).

RESULTS AND DISCUSSION

The study sites considered for the present investigation are saline-alkali (saline-sodic) and Halomorphic in nature as is evident from the high values of ECe (1:1) ESP and high water table. Monsoonic climate, excessive amount of salt in soil, aridity and restricted drainage are the causal factors for development of these soils. The pale yellow to olive and light grey to olive colours of the soils observed at the study sites also characterize these soils.

The relative proportion of sand silt and clay in the soils of the sites are indicative of the soil being of sandy loam type.

Comparatively high bulk density and low porosity of soil at site II reflects that soil at site II is more sandy and more aggregated than the soil at site I. The bulk density and porosity shows considerable variation throughout the year depending on the variation in the organic matter content, salt status and microbial activities in the soil. A positive and significant correlation has been observed between the organic matter content of the soil with both bulk density and porosity of the soils of both the sites ($r= 0.83$ $P<0.001$ at site I, $r= 0.76$ $P<0.001$ at site II for bulk density; $r= 0.97$ $P<0.001$ at site I, $r= 0.83$ $P<0.001$ at site II for porosity) (Figure 1).

Water holding capacity and field capacity are the two soil moisture constants of considerable ecological importance. Remarkable variation both in water holding capacity as well as in field capacity was noticeable in soils of both the study sites along with seasonal fluctuations of organic matter contents. Both water holding capacity and field capacity showed a significant positive relationship with organic matter content of the soil ($r= 0.92$ $P<0.001$ at site I, $r= 0.90$ $P<0.001$ at site II; $r= 0.96$ $P<0.001$ at site I, $r= 0.86$ $P<0.001$ at site II) (Figure 1).

Relatively higher infiltration rate of the soils from site II is explainable on its coarsy textural makeup with higher proportion of non-capillary pores making percolation is easy. Soils of site I is more clayey than site II. Although the total pore space here is more but the much of it is represented by capillary pores embracing more constrictions. Unless such soil possess good aggregate structure, water may not drain rapidly enough. Infiltration rate in the soil profile at the two sites showed a significant positive relationship with organic matter (r= 0.81 $P<0.001$ at site I; r= 0.96 $P<0.001$ at site II) content of the soil (Figure 1).

Infiltration rate of soil was maximum in the summer season due to greater accumulation of soluble salts from lower to upper horizon and thereby increasing the concentration of ambient solution around clay particles which counterbalances dispersion. It is minimum during rainy seasons owing to low concentration of electrolytic resulting in enhanced dispersion of clay particles and thus local displacement in the surface layers resulting in clogging of soil pores and formation of a high impedance crust which limit water transmission.

Saturated hydraulic conductivity in the soils of two sites was variable round the year. The maximum saturated hydraulic conductivity recorded in the summer season is attributed to the heavy accumulation of organic matter on the surface layer of the soil due to minimum mineralization activity. That the saturated hydraulic conductivity in the soil was minimum during rainy and winter seasons was ascribed to be due to less accumulation of organic matter. In rainy season, high precipitation abundance of water results in the swelling of clay. Which in its turn lowers the size of pores and acts as an additive to limit the freedom of water flow in the profile (Park and O'connor, 1980).

Saturated hydraulic conductivity of the soil of both the study sites showed positive significant correlation (r = 0.76 $P<0.001$ at site I; r = 0.94 $P<0.001$ at site II) with the organic matter content of the soil (Figure, 1) and with soil moisture the value was r= 0.68 $P<0.01$ at site I; r= 0.83 $P<0.001$ for site II (Figure, 2).

Possible mechanism responsible for reduced transmission of water through soil system with increase in ESP in the soil under predominance of $Na+$ as cations has been subject of many recent studies. In later work with pure clay minerals observed that mineral swelling is a relatively less important mechanisms for bringing reduction in the hydraulic conductivity at low ESP values.

Organic matter contents of the soil accumulated during summer month was considered equally responsible to step up intrinsic permeability of soil to water through prevention of dispersion and stimulating flocculation to blocking of pores. Permeability of soil to water at site II indicates that soil permeability is mainly a function of larger pores. Because soil at site II is more sandy relative to that of site I.

Hydration of clay and its resultant swelling are responsible to a considerable extent in the seasonal variation in hydraulic conductivity and intrinsic permeability to water. The electrostatically charged clay particles attract cations with which they form a diffuse double layer. This process of imbibition causing swelling is especially pronounced when the ambient solution is more dilute. With more dilute solution continued swelling relieves the osmotic pressure differential between the clay domain and the ambient solution and weakens, the interparticle bonds. A combination of this osmotic swelling with mechanical disturbance of the soil system can lead to a rupturing of interparticle bonds. So that adjacent particles separates and the clay fraction undergoes dispersion which alter the geometry of the soil pores and results in a decrease in intrinsic permeability to water.

Combination of low salt concentration and high ESP are the conditions most likely to cause swelling dispersion and reduction in permeability to water. The collapse of aggregates pores may proceed to the extent that an open surface can become sealed, moreover dispersed particles can move with percolating water and migrate into the soil profile forming distinct layer 'clay pan'.

Moisture retention at 1/3 bar in the soil profile at the both sites was maximum in the summer season owing to greater accumulation of neutral soluble salts from lower to upper horizon through capillary rise concomitant with the soil solution and minimum in winter and rainy seasons owing to less accumulation of organic matter content and soluble salts, which shift moisture retention from higher to lower levels at all tension (1/3, 1, 15 bar) values. Moisture retention at 1/3 bar in the soil profile at both sites shows a significant positive correlation with organic matter content of the soils (r= 0.96 < 0.001 at site I; r= 0.91 P<0.001 at site II) (Figure, 1)

A positive significant correlation with organic matter content was also evident at 1 and 15 bar tensions (r= 0.99 P< 0.001 at site I, r= 0.98 P<0.001 at site II for 1 bar (Figure, 1); r= 0.86 P<0.001 at site I, r= 0.73 P<0.001 at site II for 15 bar) (Figure,2).

Increase in EGP resulted in increased soil moisture retention at 1/3, 1, 15 bar tensions although at lower tension moisture retained was higher at low ESP values (Figure, 3). Increased moisture retention with increasing ESP was reported by Abrol and Bhumbla, (1978) at 0.33, 0.5, 1 and 15 bar work of Kultik (1969), however, indicated that the type and amount of clay exerted a major influence on moisture retention at various tensions and that the influence of cations was secondary. Exchangeable Na+ affects moisture retention through its dispersive action on soil colloids and altering the pore size distribution reduced number of relatively large pores and total porosity and increased number of relatively small sized pores at high ESP values as a result of soil dispersion is responsible for the observed differences in moisture retention at low and high tensions, respectively. Because of the impeded drainage conditions prevalent the saline sodic soils, moisture retention at low soil water tensions, including near saturation, assume importance particularly in the surface soil layers.

The osmotic pressure of the soil solution varies inversely with the changes in the moisture content of the soil within the root zone as a result of water movement . Further, the withholding of water from the plant through surface force action by the soil, and the effect of this retentive force is theoretically additive to that of physiological unavailability of water induced by the osmotic pressure of the soil solution.

Availability of water in the soil profile at site I showed positive correlation with organic matter content (r= 0.77 P<0.001 at site I, r= 0.13 at site II). The reason that site I was less coarsy than II site so that organic matter showed significant positive correlationship with available water capacity owing to its better effectivity at field capacity than PWP for site I whereas this effectivity was better at both field capacity and PWP for site II.

Moisture content in the soil profiles at the two study sites showed considerable variation round the year. The maximum moisture content regarded in the rainy season is attributed to the heavy rainfall and depleted moisture level in the soil profile during winter and summer season due to low precipitation and high evaporation.

pH of the both sites also showed variation throughout the year. A significant correlations (r= 0.95 P<0.001 at site I and r= 0.96 P<0.001 at site II) was observed between soil pH and field moisture content (Figure, 2). Relatively higher pH values in the soils during monsoon months at both sites were due to the leaching of water soluble salts by the percolation of rain water to the deeper layers and hydrolysis of exchangeable Na^+ with the formation of sodium hydroxide in the upper soil zone. Lower pH value during summer and winter months were due to drying of soils which increased the concentration of water soluble salts through capillary rise simultaneously pushing the sodium ions towards the colloidal particles.

Relatively low organic matter content in soils at both sites during monsoon periods is attributed to the increased rate of microbial decomposition on account of rejuvenated microbial activity under favourable conditions of the environment. Organic matter in soil showed a negative correlation with field moisture (r= 0.93 P<0.001 at site I; r= -0.92 P<0.001 at site II) (Figure, 2) values and with pH of the soil (r= 0.87 P<0.001 at site I; r= 0.83 P<0.001 at site II) (Figure, 3).

Relatively higher values of total nitrogen in the soils during rainy season reflected the increased rate of nitrogen fixation as veil as extra cellular release by soil microflora chiefly by certain blue-green algae (BGA) which colonize these haloxeric environments (Choudhuri and Sharma, 1975) and high rate of organic matter decomposition with subsequent release of some mineral nitrogen .Total nitrogen content of the soil at the two sites showed a positive relationship with soil moisture and pH (r= 0.89 P<0.001 at site I; r= 0.98 p < 0,001 at site II for soil moisture (Figure, 2) r= 0.66 P<0.01 at site I; r= 0.88 P< 0.001 at site II for pH (Figure, 3). Low nitrogen content and high C/N ratio are indicative of eneffectivity of the humification processes coupled with the loss of nitrogen from the soil profile through denitrification, direct volatilization of ammonia and other gaseous forms of nitrogen during the dry periods of winter and summer months, while low C/N ratio is attributed to the increased rate of decomposition and mineralization of organic matter which was added to the soil during the adverse growth conditions of winter and summer season of the preceeding year.

Available phosphorus showed a decreasing trend subsequent to rainy season at both sites. The low contents of available phosphorus in these soils during summer months reflects the depressing effect on the availability of phosphorus due to the presence of excessive amount of soluble salts and high ECe which are characteristically associated with these habitats. Significant correlations exist between available phosphorus with soil moisture and pH of the soil ($r= 0.94$ $P<0.001$ at site I; $r= 0.82$ $P<0.001$ at site II for soil moisture (Figure, 2) $r= 0.88$ $P<0.001$ at site I; $r= 0.93$ $P<0.001$ at site II for pH (Figure, 3).

Variation in salinity levels within the root zone round the year is the normal consequence of climatic variables. Seasonal variation in salinity levels of salt affected soils have been studied earlier by Sen Gupta (1984). They reported a low salinity in the upper soil horizons during rainy season and a reverse case during dry winter and summer months. Appraisal of soil salinity of the study sites made by measuring the electrical conductivity of the (1:1) and (1:5) extracts reflected their high salt status. Relatively lower ECe values during rainy season are due to the leaching of soluble salts through downward movement of water. Evapo-transpirational loss of moisture from soil during dry hot summer season resulted in the accumulation of salts in the profile through capillary rise which is evident from the high values of ECe (1:1);(1:5) extracts encountered in summer months. The better estimate recorded for ECe (1:5) extracts than ECe (1:1) extracts owing to presence of huge amount of CO_3^{--} and HCO_3^- in the soil profile at both sites.

Negative relationships are established between EC (1:1) and field moisture content ($r= -0.92$ $P<0.001$ at site I and $r= -0.92$ $P<0.001$ at site II) and also with ECe (1:5) and soil moisture contents ($r= -0.85$ $P<0.001$ at site I and $r= 0.94$ $P<0.001$ at site II) (Figure 2). Highly significant correlation exists between ECe (1:1) and ECe(1:5) soil water extracts ($r= 0.95$ $P<0.001$ at site I; $r= 0.97$ $P<0.001$ at site II) and it appears that dilution (1:5) gives a better estimate of ECe (Figure, 3).

The ionic constitution of these saturation extracts showed that Na+ among cations and HCO_3 and CO_3 among anions dominated the soils at both sites throughout the year. This reflects that $NaHCO_3$ and Na_2CO_3 were the major salts responsible for the development of salinity and alkalinity at both sites.

Among anions, chloride and sulphate however, showed marked variations in their concentration round the year in the soil profiles at both sites due to their high mobility while carbonate and bicarbonate remained high round the year due to their low mobility in the soil profiles and addition to the soil through chemical reaction induced by high pH, ncreases of bicarbonate and carbonate content in the soil accelerates the sodification process under such conditions, the less soluble such as Ca^{++} and Mg^{++} are precipitated as insoluble carbonates thus increasing the percentage of adsorbed sodium in the soil system.

Exchangeable Na^+ which remained above 15 round the year at both sites evidently reflects the high sodium loading, of the soils concomitant to precipitation of divalent cations. Negative relationship exists between exchangeable Na^+ and field moisture content ($r= -0.97$ $P<0.001$ at site I; $r= -0.90$ $P<0.001$ at site II) (Figure 3). Relatively lower values of exchangeable Na^+ during rainy season is ascribable to the hydrolysis of soil sodium complex. Hydrogen ion, which are abundant in the soils during rainy season, displace some Na^+ from the soil exchange complex and the liberated Na^+ ions from sodium hydroxide in the soil solution thereby elevating the soil pH. The NaOH reacts with CO_2 and forms sodium carbonate.

$2Na^+ + 2OH^- + H_2CO_3\,(H_2O+CO_2)\text{-}Na_2CO_3+2H_2O$

During the summer season when water is not freely available, the accumulation of sodium due to capillary rise results in the replacement of hydrogen ion from the colloidal complex.

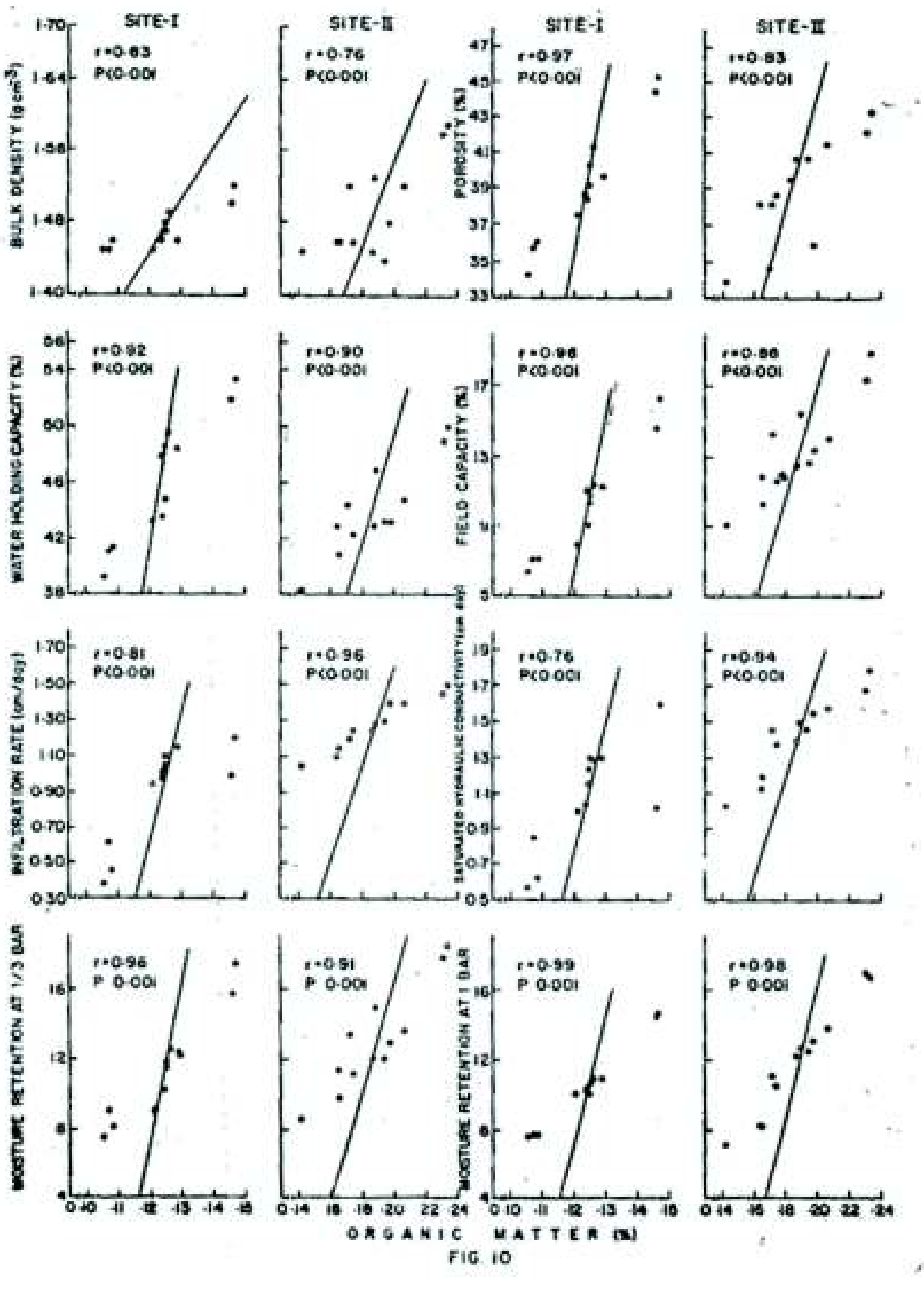

FIG. 10

Figure 1 : Regression Lines Showing Correlations Between Bulk Density, Porosity, Water Holding Capacity, Field Capacity, Infiltration Rate, Saturated Hydraulic Conductivity, Moisture Retention At ⅓ And 1 Bar With Organic Matter Content of Soils of The Two Study Sites

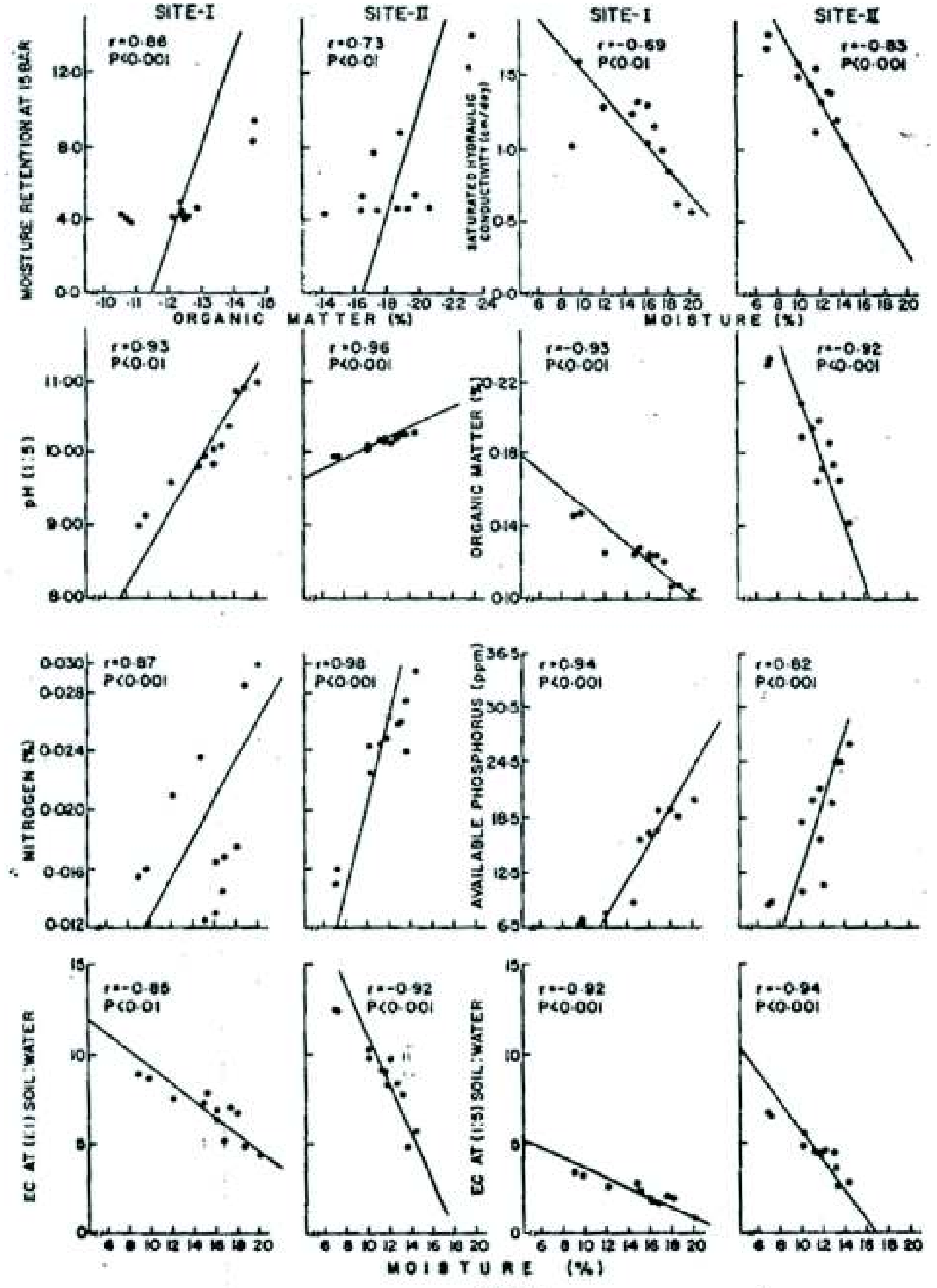

FIG. 11

Figure 2 : Regression Lines Showing Correlations Between Moisture Retention At 15 Bar With Soil Organic Matter; Saturated Hydraulic Conductivity, pH(l:5), Organic Matter, Nitrogen, Available Phosphorus, ECe (1:1) and ECe (1:5) With Moisture Content of The Soils of The Two Study Sites

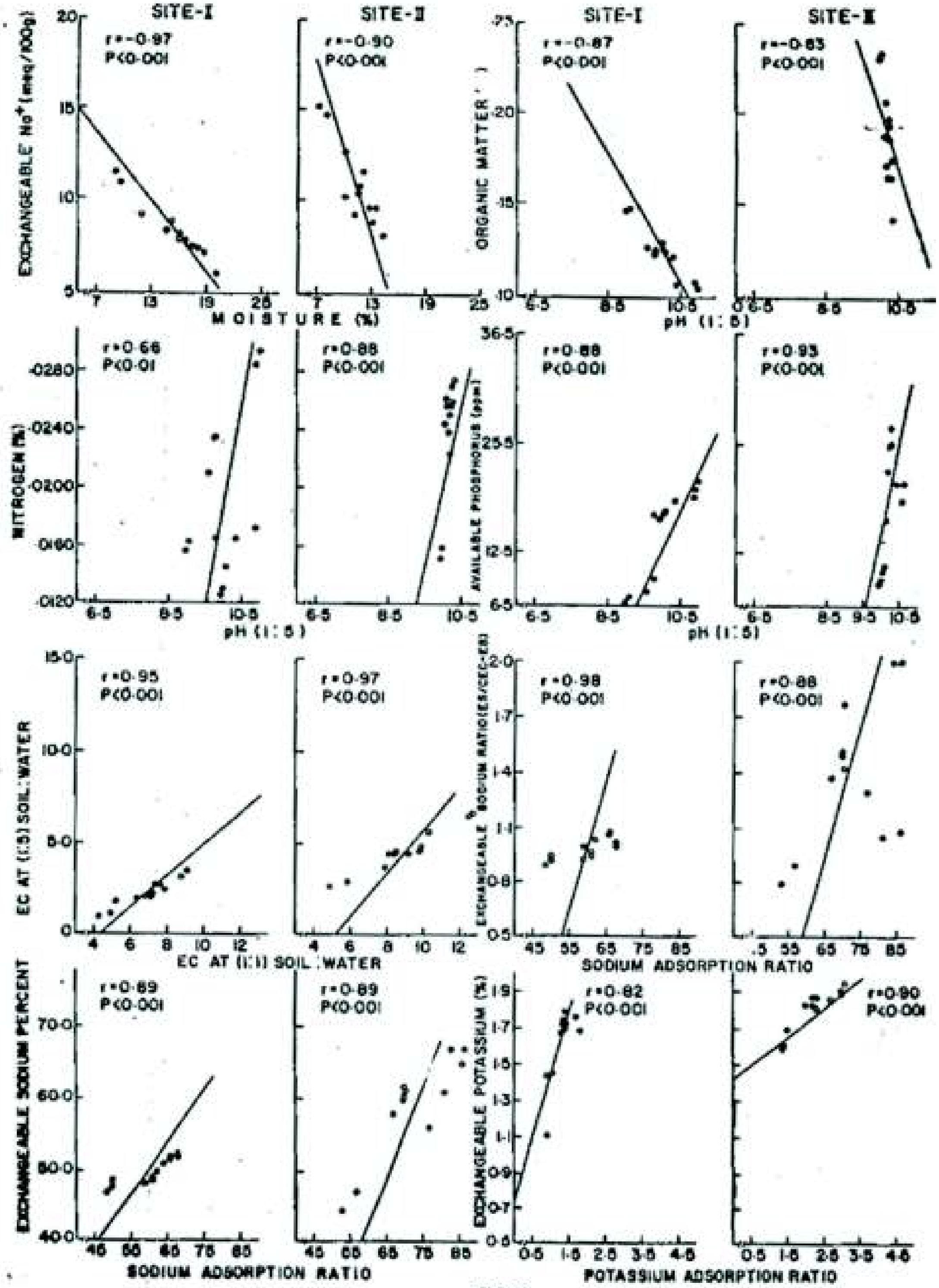

FIG.12

Figure 3 : Regression Lines Showing Correlations Between The Exchangeable Sodium With Moisture; Organic Matter, Nitrogen, Available Phosphorus With pH (1:5); ECe (1:5) and ECe (1:1); Exchangeable Sodium Ratio, Ssp And Sodium Adsorption Ratio; Exchangeable Potassium Per Cent And Potassium Adsorption Ratio of Soils of Two Study Sites

Sodium adsorption ratio which shows remarkable variation round the year at both sites evidently reflects the greater accumulation of soluble salts through soil profiles.

Positive significant correlation recorded between SAR and exchangeable NA+ ratio at both study site ($r= 0.88$ $p< 0.001$ at site I; $r= 0.88$ $P<0.001$ at site II)(Figure 3) and highly significant correlationship exist between sodium adsorption ratio and exchangeable sodium per cent ($r= 0.89$ $P<0.001$ at site I; r= O.89 $P<0.001$ at site II) at both study sites (Figure, 3).

Also significant positive correlation was found between potassium adsorption ratio and exchangeable potassium per cent at both study sites ($r= 0.82$ $P< 0.001$ at site I; $r= 0.90$ $P< 0.001$ at site II) Figure, 3) (Ciobanu et al. 2004; Goonzolez, et al., 2004; Mansoor et al. 2008; Nargis et al. 2010).

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