INTRODUCTION

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ORIGIN

Turmeric is a native of southern Asia and is cultivated in India from very ancient times. The crop is grown on a large scale in India, Indo China, Lanka and East Indies.

AREA AND PRODUCTION

In India, it occupied 82,000 hectares during 1978-79 and the production was 1,47,000 tonns. It is grown to small extent in all states but the major area lies in Andhra Pradesh, Tamilnadu, Orissa, Maharashtra, Kerala and Assam. In Maharashtra state, turmeric is grown in about 9000 hectares mainly in Sangli, Satara and Kolhapur districts. Annual production is about 16,000 tonns.

VARIETAL IMPROVEMENT

The plant belongs to the natural order - Scitamineae and family Zingiberaceae.

The major important species are :

a) *Curcuma amada* (Ambe halad)

b) *Curcuma augustifolia*, Roxb (Tarakhira)

c) *Curcuma aromatica*, salish (Ran halad)

d) *Curucma longa* Linn and

e) *Curcuma domestica* valeton (Halad)

Curcuma longa Linn is commonly grown all over India, It is perennial herb, about 60 to 80 cm in height with a short stem and tufted leaves. The rhizomes, which are short and thick, constitute turmeric of commercial importance.

The crop is propagated vegetatively from the rhizome or corm, when planted it sends up shoots and leaves. The leaves are lanceolate and bright green in colour. The root system develops at the base of the plant which swells into round corms. The root generally penetrate in the soil to a depth of about 20 to 25cm. Varieties of commercial importance are Rajapuri and Karadi (Soni) in Maharashtra and Lakhandi in Cuddapah in Andhra Pradesh and Tamilnadu and Duggirala in Orrisa.

ECOLOGY

Turmeric is a tropical crop which requires hot and moist climate and temperature ranging from 11^{o}C to 40^{o}C for its proper growth. It is very sensitive to low temperature.

The crop grows well in loamy or alluvial soil which is well drained, loose and driable. It can not stand waterlogging or alkalinity. Turmeric can be grown as an unirrigated crop in heavy rainfall tract and as an irrigated crop in moderate rainfall area.

CULTURAL METHOD

For the cultivation of turmeric ridges and furrows are prepared about 75 cm apart. Mother sets, which are oval and round are preserved from the previous crop and used for planting. Only mature and sprouted sets are selected for planting on both the sides of ridges about 1/3 above the bottom of the furrow. Only one set with eye bud facing upward, is planted per hill about 10cm deep. The distance between two sets varies from 20 to 25cm.

Generally the sets are planted from 15th May to 15 June either before or after high irrigation. After that irrigation is given at an interval of 10 day. In all 20 to 25 irrigations are required.

The crop germinates in 4 to 6 weeks. The recommended dose of fertilizers in Maharashtra is 120 to 125 Kg N, 37 Kg P_2O_5, and 37 Kg K_2O per hectare. Acyl phosphate and potash are given as basal dressing. Half the dose of Nitrogen is given after germination and the remaining half dose after six weeks.

HARVESTING AND CURING

The crop is ready for harvesting within 8 to 9.5 months in January to March. When the leaves turn yellow and begin to dry and drop down, the stalks are cut a fortnight before the rhizomes are dug out. The rhizomes after digging are cleaned by removing the soil, roots etc. and mother and finger rhizomes are separated. Well matured mother rhizomes are preserved as seed for the next year's planting. The cleaned finger sets are boiled in an iron pan and after boiling rhizomes are spread on a hard ground for sundrying. When the rhizomes are fully dried are cleaned and polished either by rubbing the material by hand against the hard ground by using polishing drums. About 20 Kg of unpolished dry material is filled in an revolving drum along with turmeric powder or "middle Chrome" and artificial dye to give it necessary colour and polish.

ECONOMIC USE

Turmeric is used as a condiment in allmost every Indian house-hold. It is also used as a colouring matter for food stuff. It is given a yellow dye which is useful for drying cotton, silk, wool, paper, wood wax etc. It has medicinal properties and used for extenal applications against pain and internally as a stimulant. It is also used as a cosmetic by Indies and in religious functions.

Turmeric (Curcuma longa L.) is an important spice grown on commercial scale in India. Turmeric is a best known spice as well as the condiment and it is used as a colouring matter in pharmacy, confectionary and food industries (Pruthi, 1976 and Purseglove et al. 1981).

Soil salinity is the threatening problem in the world. Therefore it is important to study the effect of salinity on growth, development and mineral nutrition of the plants. We have selected two varieties of Curcuma longa - Sugamdhum and Erode and have made an effort to study the physiology of the plant under saline conditions.

Salinity is the main problem, the farmers are facing today. So we have tried to study the effect of salinity on this crop.

SOIL SALINITY

Soil Salinity is the threatening problem in agriculture. Millions of hectares of land throughout the world are too saline to produce economic yield of crop plants. More and more land is becoming non-productive each year as a result of poor soil managements, which results in salt accumulation. According to Throne and Peterson (1955) 25% of the earth's surface can be considered as saline. In India, the states where this problem is serious are U.P., Haryana, Gujarat and Rajasthan estimating about 12 million hectares of land (Sharma & Gupta, 1986) in Maharashtra also several hundreds of hectares of land under sugarcane cultivation is becoming saline.

Salinity is a potential problem for semiarid and arid regions of the world. Although all soils contain some amount of soluble salts which are essential for crop production, but problem develops only when soluble salt accumulation in the soil reaches a level harmful to growth of plants.

Salinity plays an important role in the very existence, behaviour and distribution of plants. It has an adverse effect on nutrition, growth and reproduction of most of the land plants. Therefore, it is of prime importance to study the effect of salinity on the physiology of plants.

A saline soil is the one, which contains excess of soluble salts or excess of exchangeable sodium which adversely affects the plant growth. The electrical conductivity of the saturation extract of such soils is greater than 4m Scm^{-1} and the exchangeable sodium percentage (Esp) is less than 15. The P^H of saline soils is usually less than 8.5.

Salinity in soil or water presents a stress condition for crop plants that is of increasing importance in agriculture. The majority of plants are relatively salt sensitive. In particular, almost all crops plants are unable to tolerate permanent saline conditions.

A salinity problem is regarded as arising when the concentration of sodium chloride, sodium carbonate, sodium sulphate or salts or magnesium are present is excess.

When the plant under such conditions is exposed to a variety of stresses. There are two views which describes the mechanism of salt stress. According to the osmotic effect view, the adverse effect of salinity is related to the decreased osmotic potential of the saline soil, while according to the specification effect view, the adverse effect of individual ions. The overall effect on salt stressed plants results in the reduction of growth. Stunted growth of plants under saline condition is the most important symptom of salinity effect. Plants growing in the saline condition are generally stunted, leaves are small, though they may be thicker than those of normal plants. Leaves of salt affected plants are often darker green than those of normal plants.

In addition, salts affect the relation of the plant with its environment, and many factors like light, temperature which under normal conditions favourably inclines the plant, affect it unfavourbly under saline conditions.

Chloride sensitive crops usually show injury symptoms when their leaves accumulate between 0.3 to 1% chloride on leaf-weight basis, depending on the crop. Typical injury symptoms are leaf born or occuring entirely at the extreme tip of older leaves and progressing along leaf rachis towards the stem. In extreme cases chloride toxicity can cause defoliation. As salinity level increases growth of intolerant plant declines, and yields are reduced leaves becomes smaller and deeper blue green than normal and leaf tips or margins become bleached, in proportion to the degree of salinity. Characteristics leaf injury symptoms are most frequent in fruit and nut crops such as brief, stome fruit, citrus, avocado and woody ornamental species. Marginal foliar bleaching and necrosis appear when the leaves accumulate more than 0.25 % of sodium or 0.5 % of chloride on a dry weight basis.

The nature of salinity effects might differ also during various stages of plant development. Latter growth stages were more affected by NaCl (Sharma 1980, 1983 and 1984).

Several workers have reported that salinity adversely affect growth and dry matter production in several plants (Tayler et al., 1975; Heikal, 1976; Georfivard spasenovski, 1987; Frota and Tuker, 1978, Ibrahim 1980, Chavan and Karadge 1980). However greater sodium uptake promotes dry matter yield of all parts in case of karley and sugarbeet indicating that sodium plays a specific role in their metabolism (Hamid and Talibudin 1976). Differential response by spinach and lettuce has been observed by Matar et al., (1975), Chavan and Karadge (1988) found that in sesbania which behaves like barley, spinach and sugarbeet indicating its well adaptability to saline conditions.

Salinity and Growth

Greenway and Munn (1980) while reviewing the mechanism of salt tolerance in non-halophytes, have catagorised the plants into 3 groups. The first group is of halophytes. Which continue to grow rapidly at 200mM - 500 mM NaCl, Spartima townsendic and sugerbeet.

The second group is of both halophytes and non halophytes which grow very slowly above, 200mM NaCl. Which includes halophytic, monocotyledons, cotton, Barley and tomatoes and the third group comprises of a very salt sensitive non-halophytes including fruit trees such as citrus, avocado and stone fruits. The salinity puts various problems and overall reflection of all these problems results in the reduction of growth, salinity causes stunting growth in glycophytes. On the other hand growth in halophytes favoured by certain amount of salt (Strogonov 1964). According to him the adverse effect of salt on growth is due to their thicker cuticle and low permeability to salts which prevents excessive accumulation of toxic ions succulence character of halophytes (Choloride types) helps to dilute the ions in the cytoplasm.

Chloride salinization causes changes in the inter cellular spaces and the changes in the properties of the protoplasm.

In chloride dominant salinity the number of vascular bundless decreases but their diameter increases. In cereals thickness of the waxy layer and cuticle increases but their length and width decreases.

B) **Salinity and Metabolism**

Salinity is the most serious problem in crop production. There are some crops which are growing in saline condition i.e. salt tolerant plants and there are some crops which are not growing in saline condition i.e. salt sensitive plants. Salinity affects various metabolic processes viz photosynthesis and respiration etc. Salinity also affects organic constituents and inorganic constituents present in the plants.

i) Carbohydrate Metabolism

Carbohydrate Metabolism is affected by the increase in salinity as well as by the types of salinity. Sarin and Narayana (1968) reported a decline in amylase activity in germinating wheat seeds under the high level of salinity. On the other hand stimulation of amylase activity under salinity has been reported in barley (Dixon and Webb, 1957) and wheat seedlings (El-Fouly end Jung, 1972). According to Strogonov (1964) this enzymes was activated similarly by NaCl and Na_2So_4. Bhardwaj, 1959 reported that both NaCl and Na_2Co_3 resulted in decline in sugars at the seedling stage as well as in the grains produced. Soluble sugars content also declined. Sheoran (1975) found that salinity resulted in the accumulation of soluble carbohydrate in the cotyledons of

Phaseolus aureus El-shourbagy and Kishk (1975), observed a decline in bound sugars. Shimose (1972), reported no effects on the total carbohydrate content of barley leaves and stems.

Munn *et al* (1982), on the basis of an extensive study, reported that the carbohydrate status of the elongating tissues of the salt tolerant variety of barely. [illegible] In the rapidly elongating region, total soluble carbohydrate was 60-100% higher at 120mM and 180mM NaCl than 0.5mM NaCl, starch was not affected by NaCl. In the mature leaves the concentration of both starch and soluble carbohydrates decreased.

i) **Nitrogen Metabolism**

Amino acids and other soluble nitrogenous compounds play essential role in plant metabolism. Because of the importance of nitrogen metabolism and nitrogenous compounds there has been much interest in the influence of environmental stress on their metabolism. Nitrogen metabolism is affected differently by type of salinity and the reponses differ in different plant species.

Nitrogen metabolism in plants is characterised by three main steps. The first step consists of the conversion of inorganic N into Organic N compounds of low molecular weight. In higher plants this step is irreversible. In the second step, synthesis of high molecular weight N compounds takes place. Low molecular weight organic N compounds and particularly anino acids serve as building blocks for synthetic reactions. The third step represents the breakdown of the N containing macromoleculars by in creased activity of hydrolytic enzymes. Disruption of plant nitrogen metabolism by salinity was attributed to decreased nitrate uptake (Rush and Epstein, 1975), decreased nitrate reductase activity (Heimer, 1973; Sharma and Garg 1983), altered amino acid synthesis (Stewart and Lee 1974, Wyn Jones and Storey, 1978) and slowed protein synthesis (Helel and Mengel, 1979; Sharma, 1980). Other studies, however, reported that salinity induced accumulation of nitrate nitrogen (Langdale et al. 1973) and had no effect on the activity of nitrate reductase (Heimer, 1973).

Plants can take up and metabolize both No_3 and NH_4 forms nitrogen salinity effects on nitrogen metabolism start right at the level of uptake of inorganic form itself. Nitrate reductase enzyme which is involved in the reduction of No_3 to No_2 is known to be highly sensitive to all types of stresses, particularly salt and osmotic stress. However nitrite reductase was affected to a much lower level.

0.5% NaCl concentration stimulated the activity of alanine aminotransferase and to a lesser extent that of aspartate aminotransferase. Similarly Sharma (1980), Sharma and Garg (1985) found that both alanine aminotransferase (GPT) and asparatate aminotransferase (GOT) showed increased activity in wheat at seedling, tillearing, ear emergence and grain filling stages under isosmotic level of PEG and NaCl. To throw more light on some of the factors a brief resume of mineral nutrition under saline condi tions have been given in the following pages :

Salinity & Mineral Nutrition

Mineral nutrition of the plants is an important aspect of the plant growth. When a plant subjected to the medium containing excessive ions then there is nutritional imbalance and it inducers mineral deficiency of some elements or sometimes toxicity in some others and whole mineral metabolism is disturbed.

When the plants are subjected to high concentration of salt then there is decrease in mineral elements present in plants.

Increased accumulation of Na^+ and Cl^- under salt stress condition has been reported by many workers (Laszlo and Kuiper, 1979; Reddy and Das, 1978; Imamul Huq and larher, 1983; Karadge and Chavan, 1979, 1983; Nigwekar and Chavan, 1987).

Sodium has been shown to relatively more harmful component of salinity (Gates et al. 1970). It clearly indicate that the differential uptake and distribution of Na^+ and Cl^- absorbed at different rates and independent of each other. The relatively high uptake of Cl^- than Na^+ in salt stressed plants could also be responsible for growth depression.

Larsan, (1967) proved in halobacterium that K^+ plays very important role in the mechanism of salt tolerance and also similar observation have been made by Walter, (1961). The role of K^+ in developing salt tolerance in plants have been studied by Bernstein, (1975). The role of K^+ has been further confirmed by the recent works of Rosema (1975, 1976) who states that K^+ produces a relatively important contribution in the total osmotic potential.

It is well known that K^+ absorption is usually reduced by excess Na^+ in the growing medium (Austenfeld, 1974; Roland, 1976; Ahmed et al, 1986; Khalid and Malik, 1987; NIgwekar and Chavan, 1987). Role of salt tolerance in mangroves and some succulents has been reported by Joshi, (1976) respectively.

Osmond (1966) has stated relatively low Ca^{2+} content of the Atriplex leaves in the field due to the presence of high concentration of Na^+ content. A reduction in Ca^{2+} uptake under saline condition in salt sensitive plants is observed by several workers (Mater et al, 1975; Guggenheim and Waisel, 1977; Laszelo and Kuiper, 1979; Chavan and Karadge, 1980; Starck and Kazinska, 1980; Divate and Pandey, 1981). At the same time there are reports of increase in Ca^+ contents in some plant species under saline conditions. (Joolka et al. 1977; Ayoub, 1977; Karadge et al, 1983 Karadge and Chavan, 1983; Weinke and Lauchli, 1980) reported that increasing the level of salinity in the root solution substantially reduces that Ca^{2+} uptake of soybean varieties differing in salt tolerance.

The uptake of Na^+, K^+ and Ca^{2+} increased with increasing salt concentration in the case of Glycophytes and halophytes. But halophytes showed only a little more uptake of Na^+ than glycophytes (Lotschert, 1970). In most species it has been reported that Na^+ is taken inside passively and distributed to all parts of plant. It is many times secreted out by well developed salt glands.

Winter et al (1976) studied the mineral ion composition of coastal desert habitats. They report that most species had high level of mineral ions mainly Na^+ and Cl^- with high Na^+/K^+ ratio ranging from 10 to 20. While in coastal habitat the content of ions and Na^+/K^+ ratio fall down considerably.

Little work has been done regarding the role of Mg^{+2} in salt tolerance. Overstreet and Jacobson (1952) reported slow obsorption of Mg^{+2} than other cation in absorbing medium. At Kinson et al. (1967) indicated that the maintainance of salt tolerance was due to increase in Mg^{2+} contents in the leaves of Aequialitis annulata a mangrove.

Bernstein (1975) has claimed that the tolerance of species for a particular salt reflects the ability of species to obsorb nutritionally adequate levels of Ca^{2+} and Mg^{2+} from the soil.

P^{5+} is an inorganic nutrient and it is clear that this inorganic nutrient is only slightly influenced by salinity. Due to high concentration of salt, the uptake and distribution of this element is slightly affected and on the other hand due to low salt concentration all plant parts are slightly elevated.

Importance of P^{5+} accumulation in the resistance to secondary salt induced stress has been reported by Wilson et al. (1970). Accumulation of this ion in different parts of salt tolerant as has been reported by many workers. (Narayanan, 1975 Chavan and Karadge 1980).

Very little information has been known about the effect of salinity on uptake and distribution of micronutrients. Fe^{3+} absorptions inhibited by higher concentration of Ca^{2+}. Salt affected soils are usually adequate in boron. The content of Zn^{2+}, Fe^{2+}, Mn^{2+} and Ca^{2+} and Zn^{2+} usually lesser and Fe^{2+} and Mn^{2+} higher than alkali soils. Strogonov (1964) has reported a decrease in Fe^{3+} content due to NaCl salinity.

In this way mineral metabolism in most of the plants is disturbed due to salinity.