Chapter 11
Strategies for the Management of Soil-Borne Pathogens and Crop Production Under Saline Environment

M. I. S. Safeena and M. C. M. Zakeel

Abstract Total agricultural land of the globe becomes insufficient due to the progressive nature of primary and secondary salinity. High salt content in the irrigation water or soil is a serious restriction factor to the cultivation of many crops. Salinity has significant influence in maintaining the balance nature of osmosis, the availability of water and nutrients, and the formation of free radicals in plant. The consequence of these factors causes undesirable effect on photosynthesis, growth, and development of numerous economically important plants. This review evaluates the management practices or strategies based on the combination of approaches through management of soil-borne pathogens, root-zone salinity management, quality irrigation, and cultural practices to accelerate the removal of salts and cultivation of salt-tolerant plants. Root-zone salinity is mainly controlled by different irrigation systems and leaching and by the use of appropriate plants to maintain the water table. There is a diverse strategy that can be applied through quality irrigation and cultural practices. Different modes of irrigation, tillage, and bio-drainage, addition of organic matters and gypsum, and application of sulfur are some of them. However, growing salt-tolerant plants along with the traditional methods of managing the saline environment take a momentum to reduce the effect of high salinity. Genetic engineering approach through the deep understanding of physiological response of plants to salinity would augment the identification of potential gens for developing transgenic plants. Application of microbes, organic matters, and green remediation also has proved the improvement of plant health and productivity under salinity and biotic stress. These management strategies provide an insight to the effective crop production under saline environment.

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11.1 Introduction

Obtaining adequate and virtuous water source is an essential factor for agriculture to produce food for the rapidly growing population in the world. This situation will be deteriorated when there is an arable land exaggerated with salinity. Seckler et al. (1999) has stated that nearly 1.5 billion population of the world will demand for all categories of diet from the water shortage and saline-prone land by the year 2025. The amount of irrigated land is shown in Table 11.1 for various regions of the world. Nearly 60% of irrigated land is located in Asian countries where population is rapidly rising with limited land for domestication. Accordingly, salinity in irrigation water and cultivating soil will unquestionably affect the food production. Umali (1993) and Epstein et al. (1980) have revealed that nearly 8–12% of the irrigated land or one billion hectares of the world's land is affected by salinity. Accumulation of salts in soil occurs through weathering of parent minerals or from the unsuitable management practices applied to the land and water resources (Qadir and Oster 2004). Although potassium, calcium, magnesium, and sodium salts are important ingredients for higher yields, the presence of excess amount of salts more than required amount causes the reduction of water intake, dehydration of plants, and finally death of plants. The accumulation of salts in surplus quantities in agricultural land is recognized as a significant factor for the reduction of crop yields in many parts of the world. In addition, irregular irrigation practices, low rainfall, high evaporation, high salt contents in groundwater, and intrusion of sea water are some reasons for the occurrence of salinity. Among the soluble salts, accumulation of sulfate (SO_4^{-2}) and chlorides (Cl^-) in the soil enhances the electrical conductivity (Ahmad and Qadir 1995). When electrical conductivity at 25 °C is higher than 4 dSm^{-1}, the soil becomes saline in nature with pH of <8.5 and 15% of exchangeable sodium percentage (ESP) (Tyagi 2003). Some soils may have both saline and alkaline

Table 11.1 Irrigated areas (millions of acres) of the world by region

E. Asia + S. Asia	131
W. Asia + N. Africa	22
Former USSR	21
North America	19
Europe	17
L. America + Caribbean	16
Sub-Saharan	3
Oceania	2

Adapted from Samad et al. (1992)

characters. As a result, both pH and electrical conductivity are high in these soils. Irrigated agriculture consumes nearly 70% of total water to produce around 36% of global food (Howell 2001). Growth and carbon metabolism of several crops are adversely affected under high salinity because of water deficit, osmotic effect, oxidative influence, and disproportion in nutritional availability (Kim et al. 2008). Salinity causes abiotic stress in plants in different degrees. Sensitive crops such as pulses and some special crops are mostly affected with the substantial reduction in growth and yield. Hence, salinity plays a major role in economy and sustainability of food production, and it is very much concerned especially relevant to cultivating land and irrigation water (Beltran 1999; Andriolo et al. 2005; Ünlükara et al. 2008). Many strategies are available for managing crop production in salinity-affected lands. The improvement and sustainability of food production under salinity can be intensified through two foremost approaches: adapting the environment to suit the plant and adapting the plant to suit the environment. This could be used either single or in combination (Tyagi and Sharma 2000; Tyagi 2003).

11.2 Effects of Salinity on Soil

Both visual observation and chemical analysis help to identify saline lands. The presence of white salt crust on dry soil surface is a common feature in saline lands. The prevalance of high amount of salt in soil forms hard columns of salt deposition inside when soil is exposed to prolonged dries and such depositions do not permit the penetration of root to deeper surface. Hence, the availability of volume of soil to grow, water, and nutrients become limited. There are some plant species which can withstand under high salt condition. Abundance of these plant species help to identify salt-accumulated lands. Chemical analysis of soil for cations is the easiest way of identifying saline soil (Aslam et al. 1993). When soil becomes saline or alkaline, most of the exchangeable sites are filled with cations, such as calcium, sodium, and magnesium. As a result, important nutrients such as potassium are not retained at required quantities. Consequently, soil fertility is declined and hinders the yield. Accumulation of sodium ions in the exchangeable sites caused soil particle dispersion and less porosity.

Major forms of soluble salts in the inland areas such as sodium carbonate and sodium bicarbonate cause a considerable enhancement in the soil pH. A hard layer of $CaCO_3$ and light-textured subsoil layers are prominent in saline soils having high quantity of calcium. The salinity is quantified in terms of electrical conductivity (EC), mg l^{-1} (p.p.m) or meq l^{-1}. This reflects the amount of different types of salt dissolved in soil water. The higher EC of the soil extract reveals the significant quantity of dissolved salt in soil water, and total dissolved solids (TDS) are expressed in $mgl^{-}1$. Quality of irrigation water, extended rate of evaporation from soil surface, and nature of drainage system may also cause variation in EC of the soil (Focht 1979; Handawela 1982; Dulanjalee and Pitawala 2008).

11.3 Effect of Salinity on Crops

Increasing level of soil salinity influences the osmotic pressure of soil solution which negatively impacts availability of water to plant for growth and development. Generally, the effect of salinity on yield is considered for individual crops, but in actual practice it is cropping system (Tyagi 2003). Germination process is initially affected by soil salinity under field condition. The reduced germination is subsequently having an effect on initial growth of plants which results smaller plants with lower leaf area for photosynthesis. Several studies reveal that the either cumulative or interaction of number of factors relevant to plant, soil, and environment, such as the rate of evaporation, concentration of soluble salt, different categories of soil, precipitation, water table conditions, type of crop, and water management practices, determines salinity buildup in the soil and crop performance. Accumulation of higher amount of sodium and chloride in plant cell causes destruction of plant cells due to Na^+ and Cl^- toxicity. Plant cells damaged by salt accumulation resulted in low chlorophyll synthesis, reduction in yield, and poor growth of apical buds due to less availability of Ca^{2+} (Munns and Tester 2008). High osmotic pressure in the saline soil creates physiological drought; hence physiological activities are disturbed which leads to a significant nutrient deficiency for the plant. Plants exposed to the stress show early signaling responses to the high salinity by ceasing the growth. Ionic salts are transported to the cell through non-specific ion channel in the plasma membrane and triggering sequence of changes in the biochemical and physiological activities of plants. During this, plants slow or cease the cell division and growth and produce stress hormones to manage the stress persuaded by salt ions (Rameshwaran et al. 2015). Magdalena and Christa (2015) have stated salt stress disrupts the cell organelles of an individual plant to different degrees. At later stage, plant show slight recovery of growth as salt ions are pumped into vacuoles and storage organs. Salt-stressed plants show variation in morphological architecture compared to nonstressed plants during the same growth period. This is obvious through a number of studies which suggest that the ability of plants either to cope with stress or be tolerant is really due to the changes in growth morphology. Increasing concentration of salt above the maximum tolerance level of crops sharply decreases the yield, and the reduction of yield of different crops may differ depending on their capability for tolerance. Salt tolerance ability of crops vary with different growth stages. Kim et al. (2016) have found that the continuous irrigation with saline water caused observable modifications in crop yields. The commonly recognized soil salinity levels for different crops is shown in Table 11.2. Some crop like *Helianthus tuberosus* L. (Artichoke) is moderately sensitive at threshold EC of 0.4 (Newton et al. 1991), while *Brassica napus* L. (canola or rapeseed) is tolerant at EC of 11.0 (Francois 1994). This observation is according to the tuber and seed yield of artichoke and canola, respectively. An EC of 4 is a general salinity rating for many traditional annual crops. McKenzie (1988) has proposed another type of rating system to assess the salinity level as follow:

1. Nonsaline (0–2 dS/m)
2. Slightly saline (2–4 dS/m)

Table 11.2 Variation in salt tolerance ability of some crops (grains, special crops, vegetables, fruits, and woody crops)

Crops	Salt tolerance parameters			
Botanical and common name	Tolerance based on	Threshold (ECe) dSm^{-1}	Rating[a]	References
Crambe abyssinica Hochst.	Seed yield	2.0	MS	Francois and Kleiman (1990)
Secale cereale L. rye	Grain yield	11.4	T	Francois et al. (1989)
Sorghum bicolor (L.) Moench sorghum	Grain yield	6.8	MT	Francois et al. (1984)
Psidium guajava L. guava	Shoot and root growth	4.7	MT	Patil et al. (1984)
Citrus sinensis (L.) Osbeck orange	Fruit yield	1.3	S	Bielorai et al. (1988)
Solanum melongena L. eggplant	Fruit yield	1.1	MS	Heuer et al. (1986)
Vigna radiata (L.) R. Wilcz. Bean, mung	Seed yield	1.8	S	Minhas et al. (1990)
Portulaca oleracea L. purslane	Shoot yield	6.3	MT	Kumamoto et al. (1992)
Lycopersicon lycopersicum var. *cerasiforme* (Dunal) Alef. Tomato, cherry	Fruit yield	1.7	MS	Caro et al. (1991)
Cucurbita pepo L. var. *melopepo* (L.) Alef. Squash, zucchini	Fruit yield	4.9	MT	Graifenberg et al. (1996)

[a] *S* sensitive, *MS* moderately sensitive, *MT* moderately tolerant, *T* tolerant

3. Weakly saline (4–8 dS/m)
4. Moderately saline (8–15 dS/m)
5. Strongly saline (>15 dS/m)

11.4 Management of Crop Production Under Saline Environment

The world will need a large quantity of food for the fast-increasing population with limited and marginal cultivated land around the world. One of the main causes for the limitation is the rapid changing of soil due to salinity. These types of lands require effective and efficient management systems to increase the cultivation and yield.

It is very obvious that the management practices of single system or technique is not adequate to solve the problems associated with the saline environment. Integrated approaches such as application of modern biology or molecular biology to produce salt-tolerant plants and traditional soil and landscape manipulation are essential to be practiced to improve and sustain the productivity of the lands with high salt. The combination of approaches can include root-zone salinity management, quality irrigation, and cultural practices to accelerate the removal of salts and cultivation of salt-tolerant plants (Rains and Goyal 2003; Goyal et al. 1999; Kaffka et al. 1999; Zeng et al. 2001; Asraf and Akram 2009; Sirisena et al. 2011).

11.4.1 Root-Zone Salinity Management

Several management strategies are practiced to regulate the crop root-zone salinity during the application of saline/alkaline water for irrigation (Boumans et al. 1988; Chandra 2001). They include important and restriction practices such as controlling the flow of saline water, meticulous leveling mostly with lower water table and high frequency irrigation, mixed use of different quality of water in diverse modes, avoiding the sensitive stage of growth for salinity by scheduling the irrigation period, chemical amelioration, etc. Reclamation of saline and saline-waterlogged soils needs drainage for evaluating excess water and salts from the crop root zone. The surface and subsurface drainage systems are considered much during the reclamation of saline soils. Minhas and Gupta (1992) have suggested that subsurface drainage technology has provided boost to control water logging and associated soil salinity by maintaining water table below a specific depth. Tyagi (2003) promoted the usage of brackish water by introducing manipulation of subsurface drainage and water table during a situation like prevailing of high water table with saline water. Salt tolerance crops having the ability of late maturing and deep rooting would be a worthy choice to benefit and lower the water table by utilizing the saline groundwater according to the nature of soil (Goyal et al. 1999). It has been proven through many studies that among the crops, alfalfa is showing the greatest performance not only to help lower the water table but also to be used as a part of a cycle of cultivation or as a long-lasting water barrier when it is necessary to control the flow of salt water from one soil to another (Brown and Hayward 1956; Bernstein and Francois 1973). Similarly, in addition to the supply of nitrogen for the next crop as green manure, sweet clover also helps lower the water table (Gismer and Gates 1988). However, a proper management must be followed to avoid yield reduction in the consequent season due to the water use by sweet clover. Superficial tillage is appropriate or recommended than plowing, when green manures are applied. Hence the salts are not returned to the surface. Therefore, management practices using plants to help lower the water table should be viewed as a long-term implementation plan in respect to root-zone salinity and a neither quick nor permanent renovation technique.

11.4.2 Quality Irrigation and Cultural Practices

It is apparent that good quality irrigation water is important to cut down the salt accumulation and water having EC below 0.5 dSm^{-1} is considered to be a good quality. However, a direct application of saline water is possible if plants grow well, giving acceptable yield and no adverse effect on soil. Boumans et al. (1988) reported that minimal quality water (EC of 4–6 dSm^{-1}) has been applied to different cultivation lands to get acceptable yield. As an alternative measurement to avoid the severe effect of salinity, fresh water and saline water can be used in both methods: blending and cyclic modes (Tyagi 2003). Several factors determine the favorable blending mode such as adequate availability of fresh water, salinity status of other types of water, categories of the crop cultivated, and marginal reduction of acceptable yield to be considered (Tyagi 2001). Many advantages can be obtained using cyclic mode which is a common method in multi-quality irrigation practices (Rhoades et al. 1992). Under the successive use of cyclic mode, both fresh and saline waters are alternatively applied to the field according to a preplanned calendar. Occasionally, there is an inter-seasonal switching of application of fresh water and saline water in different periods of cultivation (Sharma and Rao 1996). A number of researches have recommended that saline irrigation water consisting high amount of salt above the appropriate values can be used effectively for cultivation of several crops for at least 6–7 years without significant loss in the yield. Though there is a great uncertainty prevailing about the prolonged effects of these practices, it should be concerned that some special improvements or treatments are needed along with poor-quality water irrigation compared to good-quality water irrigation in order to maintain satisfactory yield level. The yield is determined not only by the prevalence of salinity in the groundwater but also, it depends on other water sources available to the crop in the form of rainwater, river etc. (Sharma et al. 2001). Sharma et al. (1993) found that pre-sowing irrigation through blended or sequential modes is influencing the final yield because the seeds germination and seedling stage of many crops are more sensitive to salinity. Hence, pre-sowing irrigation avoids early stress exposure and retains crop stand. Therefore, the effect of salinity and its influence on final yield can be reduced by applying some certain techniques such as crop sequencing or crop rotation, crop substitution, cultivating under favorable season, maintaining precision level of land with adequate drainage system, and conserving rainwater for irrigation. Deep plowing can be avoided on saline soils since it will bring salts up to the soil surface. Zero plowing should be considered for strongly saline soils. For sodic soils, deep tillage may be beneficial to break up the hardpan and improve infiltration, as well as to bring any calcium salts present in the subsoil to the surface. A field investigation should be conducted before attempting deep tillage (Gurung and Azad 2013). Adding of carbon-based materials will avoid the surface drying of soil surface rather than decreasing salinity. It will also improve water-holding capacity and permeation, cation exchange capacity of soil as such more plant nutrients are absorbed, and drainage capacity; as a result, washing of unnecessary salts are possible (Qadir and Oster 2002; Qadir and Schubert 2002; Qadir et al. 2007; Murtaza et al. 2009; Murtaza et al. 2013). Green manure, animal manure, charcoal, and rice straw can be used as organic manure. In addition, sodium absorption ratio of soil can be reduced by leaching of salts using monsoonal rains or inundating land with irrigation water. Amount of water required for this purpose depends on the salt contents in the soil and the leaching depth. Salt concentration and quantity of the input water should be lower than the output water to have successful results by reducing accumulation of salts in the lower part of the land through leaching (Minhas and Bajwa 2001). Regardless of all the progressive points related with drainage of salt-affected areas, the drainage technology could gain momentum with the possibility of bio-drainage (growing high water transpiring trees) in waterlogged saline areas, mainly along the irrigation canals (Jeet Ram et al. 2008; Chaudhari et al. 2012a, b).

Applying gypsum to soil will be more effective when it is rich with sodium ions. Gypsum is the source of calcium which is enabling to exchange with excess sodium present in the soil (Raza et al. 2001; Chaudhry et al. 1984; Haq et al. 2007). The cost efficiency of different amendments was explored by Ghafoor and Muhammed (1981) and concluded that gypsum is much economical than the other treatments. Hussain et al. (2000a) have assessed the success of gypsum application and soil ripping to manage saline-sodic soil irrigated with brackish groundwater. The crop yield data of the study has showed that gypsum application in combination with ripping had considerable additional effect than either of the two treatments alone. Addition of equal amount of gypsum to the soil to the content of sodium in the irrigated water evidenced relatively a minimum effect on the crop yield when compare to the similar study conducted with normal soil irrigated with brackish tube well water (Hussain et al. 2000b). Application of sulfur helps to lower the pH of saline soils. Soil microorganisms oxidize the sulfur into sulfuric acid, and H+ ions and sulfuric acid replace the sodium ions. Kahloon and Gill (2003) have stated that sulfurous acid generator can be used to treat the saline water. However, economically this technology was much more costly due to initial cost of the generator and cost of sulfur, and it's burning as compared to other saline water management options (Zia et al. 2006).

11.4.3 Use of Salt-Tolerant Crops

There is a wide-ranging variation in functions among the same and different species of plants when they are exposed to salt stress (Glenn et al. 1999). Therefore, the use of genetically modified salt-tolerant crops would be one of the strategies to improve the productivity under saline environment. However, it is recommended to use the genetically manipulated salt tolerance crops along with the traditional approach of managing the saline soil and water (Epstein 1985). Naturally many crops show different levels of tolerance to salinity; among them canola, rye, oats, millet, sugar beets, cotton, and barley are considered to be the most tolerant crops. Insight understanding of physiological response of plants to the salinity will enlighten the role of potential genes for stress tolerance (McNeil et al. 1999; Epstein and Rains 1987). Gong et al. (2001) has made available a list of genes from sensitive mutants that are regulated by salt stress. In addition, several genes have been identified that affect transmembrane transport channels in membrane including the gene controlling the function of calcium in transport system (Yermiyahu et al. 1994; Lui and Zhu 1998). Zhang et al. (2001) have produced salt-tolerant transgenic plants *Brassica* and tomato which can accumulate increased sodium in vacuoles and foliage, respectively (Zhang and Blumwald 2001).

11.5 Application of Microbes and Green Remediation in the Alleviation of Soil Salinity, and Management of Soil-Borne Pathogens

11.5.1 Disease Suppression Through Microbial Agents Under Saline Environments

Rangarajan et al. (2003) reported that indigenous *Pseudomonas* strains suppressed sheath blight of rice by 19 to 51%. Four strains of *Pseudomonas* suppressed the disease of bacterial leaf blight and sheath blight of rice of which three were potential candidate under natural as well as saline environments. Best performed candidate under saline environments was MSP538 from the site which reduced the bacterial leaf blight by 82%, and this strain was identified as *P. putida*. They further propounded that the level of disease suppression of five of the strains increased marginally under saline conditions. Local strains are more potent in the inhibition of the stress as compared to introduced ones. The efficiency of such strains may also be augmented considerably (Gopalaswamy, 2001).

Application of some potent strains such as MSP377 (*P. fluorescens*), MSP497 (*P. putida*), MSP504 (*P. fluorescens*), and MSP573 (*P. fluorescens*) was tested against bacterial leaf blight and sheath blight. It was seen that these bacterial agents can suppress both bacterial leaf blight and sheath blight diseases under nonsaline and saline soil environments. These isolates possess great potential for the acceleration in the development of biological control agents to be used in coastal environment (Egamberdieva 2012).

Pseudomonas spp. use direct antagonism, production of several metabolites with antimicrobial activity toward fungi and cell wall-degrading enzymes to show the biological control activity (Haas and Keel 2003). *Pseudomonas chlororaphis* produces antibiotics, inhibitory molecules against proliferation of *Helminthosporium solani* (Assis et al. 1998; Chin-A-Woeng et al. 1998; Martinez et al. 2006; Carlier et al. 2008). Moreover, *P. chlororaphis* TSAU13 showed some antagonistic impacts on a wide range of plant-pathogenic fungi like *F. oxysporum f. sp. radicis-lycopersici*, *F. solani*, *Gaeumannomyces graminis pv. tritici*, *Pythium ultimum*, *Alternaria alternate*, and *Botrytis cinerea* (Egamberdieva and Kucharova 2009). *P. chlororaphis* TSAU13 strain was responsible for the enhancement of plant growth and yield of cucumber and tomato due to their competitiveness and persistence under saline soil environment. Moreover, *Bacillus* UW85 has been found to suppress the soil-borne plant due to the production of the antibiotics zwittermicine and kanosamine (Handelsman and Stabb 1996; Milner et al. 1996a, b).

11.5.2 Soil Salinity Removal Through Microbes and Organic Additives

Abiotic stresses usually work together with biotic stresses. For example, a crop that was grown under saline condition frequently shows more vulnerability to attacks from insects, fungi, or mites, and a crop prone to these attacks appears greater sensitivity to salt stress. Naturally colonized and soil-borne beneficial microbes around the root zone facilitate nutrient absorption and maintain health of the root in the course of biotic and abiotic stress (Hashem et al. 2016; Ab-Allah et al. 2015). It has been revealed that above physiological processes can be further enriched by using the plant growth-promoting rhizobacteria (PGPR) as an enhancing and effective agent in plants such as *Pisum sativum* (Meena et al. 2015) and O*ryza sativa* (Yadav et al. 2014). Egamberdieva et al. (2017) have proved two such *Pseudomonas* strains that were tested on soybean (*Glycine max* L.); plants under saline condition and biotic stress (*Fusarium solani*) have performed significantly very well by stimulating and improving the growth, yield, antioxidant enzyme activities, and proline concentration. Similarly, the plant growth-promoting bacteria (PGPB) have shown promising effects in increasing crop tolerance to salinity by avoiding excessive absorption of sodium (Mayak et al. 2004). Ruiz-Lozano et al. (1996) have demonstrated that application of *Glomus* species of arbuscular mycorrhizal fungi to lettuce grown under saline condition improved photosynthesis, stomatal conductance, and absorption of mineral nutrients, minimized effect of salt stress, enhanced osmotic regulation, and had a direct effect on synthesis of plant hormone. Bioremediation is a one of the healthy approaches to maintain clean environment in the plant root zone and suppress the effect of stress to the plant for ultimate improvement of yield. This strategy is practiced through the biological control, improved soil infiltration, and leaching of excess salts from the root zone (Hamideh Nouri et al. 2017). Accordingly, both sterilized and non-sterilized composts and biochar have effectively remediated a saline-sodic soil leached with reclaimed water (Vijayasatya et al. 2015). The adaptation mechanisms of halophytes are maintained through salt accumulation, excretion, and exclusion processes which have made them to use as potential plants of "salt remover" rather cultivating salt-tolerant crops alone to manage the saline soil (Mirza Hasanuzzaman et al. 2014). There are many evidences of the use of halophytes in phytoremediation of salt-affected soil since they are environment-friendly, safe, and clean processes (Rabhi et al. 2008; Ashraf et al. 2010; Qadir et al. 2007; Ravindran et al. 2007). Hence, phytoremediation has shown an active amelioration of saline condition comparable to the chemical amendments that is involving with high cost cultivation and possibly creating polluted environment. In addition, halophytes are considered to be effective means to obtain salt-tolerance genes and gene regulatory sequences (Xiaoqian Meng et al. 2018; Mishra and Tanna 2017). The enhancement of soil quality through organic amendments is another technique to mitigate salts in soil in addition to the enhanced effect on crop production and plant health (Ansari and Mahmood 2017). Youssef Ouni et al. (2013) and Abdelbasset Lakhdar et al. (2009) have stated that application of composted municipal solid waste (MSW) and palm waste (PW) composts with high organic content and less inorganic pollutants could be an alternative and promising material to protect plants from adverse effect of saline soil. Many experiments have revealed that application of organic matters to the soil in the form of composted and uncomposted has significantly suppressed the diseases caused by a number of soil-borne pathogens such as bacteria, fungi, and nematodes (Nuria Bonilla et al. 2012; Bailey and Lazarovits 2003; Aryantha et al. 2000; Hoitink and Boehm 1999). The variation in biotic and abiotic soil parameters and the interaction among many components of them would determine the pathogenicity and disease development by soil-borne pathogens (Alabouvette et al. 2004). However, depending on the pathogenicity and type of organic amendments, there will be variable responses in suppression of biotic stress (Weller et al. 2002). In addition, the plant also plays a significant role in this phenomenon, and the stimulation of plant protection mechanisms could be a vital factor of compost suppressiveness (Hadar 2011; Yogev et al. 2010). Reigosa et al. (2002) have revealed that the allelopathy plays a major role when signal receptors of plant are much affected by severe biotic and abiotic stresses. The tolerance/resistance to the stress conditions would improve either by increasing or decreasing the threshold level of concentration of allelochemicals (Einhelling 2004). Plants which are under stress environments show higher allelopathic activity not only due to increasing concentration of allelopathic compound but also by maintaining correct composition of them (Bais et al. 2004; Gouinguené and Turlings 2002).

11.6 Conclusion and Future Prospects

The progressive nature of high salinity which affects the cultivating agricultural land can be minimized through a number of management strategies. Rather considering an individual crop, many times we have to view in the way of cropping system when some management strategies are applied to control salinity. The combination of strategies such as root-zone salinity management, quality irrigation and cultural practices, and cultivating salt-tolerant plants will provide the new avenues for the sustainable crop production under different saline environments. In addition, the application of microbes and green remediation techniques through the addition of organic matters, bioremediation, phytoremediation, and allelopathy have shown promising effect in alleviating the effect of salinity and managing biotic stress to improve the crop production.

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