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Original Article

Green manure for soil salinity reclamation- A comprehensive review

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ABSTRACT

Large areas of the world are affected by high levels of soil salinity. Global warming causes a rapid rise of the sea level and enhancing new salt-affected areas inundating new agricultural land through saltwater intrusion. Salinity management through breeding strategies, land management or organic amendment could be wise strategies for salt management. Exogenous application of legumes as green manure can potentially reduce negative effects of soil salinity through growth improvement, ionic homeostasis via enhancing Ca/Na ratio in soil, adding organic matter, over expressing SOD, POD, CAT, APX, and lessening membrane leakage that upsurge crop productivity in saline environments. Such contribution to the sustainable agricultural systems is considered an alternate way towards enhancing crop cultivation in saline ecosystems. This review focused on the mechanisms of green manuring crops in soil salinity reclamation and subsequent contribution on crop growth and development.

Introduction

In Bangladesh out of 2.86 m ha of coastal and off-shore lands, about 1.06 m ha of arable lands are affected by varying degrees of salinity (SRDI 2010); and the salinity affected area is increasing with time due to global climate change and related natural calamities. A large amount of land in southern part of Bangladesh is unavailable for cultivation because of this salinity problem (Hoque *et al.*, 2021b). Several crops have previously been reported as being salt susceptible in both the seedling and reproductive stages leading to a reduction in yield of more than 50% in crops exposed to 6.65 dS m^{-1} EC (Singha *et al.*, 2021; Hannan *et al.*, 2020a; Zeng and Shannon, 2000). Increased salinity is one of the major abiotic stresses that responsible for destructive yield loss (Ivushkin *et al.*, 2019; Hanna *et al.*, 2020). Excessively soluble salts and replaceable sodium contained in the saline soils are major problems associated with crop cultivation (Paz *et al.*, 2019). Presently, soil salinity is a global problem (Chen *et al.*, 2019; Hannan *et al.*, 2020b). Therefore, preventing salinity is a key to improving plant productivity in sea belt regions of the gobe (Wang *et al.*, 2019). The presence of salt could exert an adverse effect on plant growth when the soil P^H is above 10, EC reaches ≥ 4 dS/m where Na^+ make the other nutrients such as K, Ca, Zn, Fe, Mg etc less available because of osmotic pressure (Hoque *et al.*, 2022). Excess salt becomes toxic to plants and high salinity can causes heavy metal toxicity which could contribute to poor plant growth in soils (Hersenbuiller, 1978; Hoque *et al.*, 2021b). Organic approaches could be great methods for sustainable soil management against soil salinity. Green manure is considered an important approach that has played great role of amelioration salinity stress. The inclusion of green manuring crops in a crop rotation is vital to improve the chemical and physical properties of the soil via increasing the labile of organic matter, N, P and K which ultimately increased crops yield (Irin and Biswas, 2022; Irin

et al.,2021b). The physical, chemical and biological properties of soil in salt-affected areas are improved by the application of GM, leading to enhanced plant growth and development. Therefore, the application of GM for soil remediation is important for sustainable land use and crop productivity (Choudhary *et al.*, 2004; Wong *et al.*, 2019)
The incorporation of legume GM crops into soil releases organic substances like organic acid, amino acids, sugars, vitamins, and mucilage (Shukla *et al.* 2011) during crop growth as well as after decomposition. Some complex molecules of GM crops takes a longer time of decomposition which provide nutrients to the succeeding and following crops and increased the crop yield (Irin and Biswas, 2020b). The incorporation of GM is an effective low-input agro-technological approach to minimize toxicity conditions induced by salinization. Many research has been done to find out methods by which saline soils can be improved to ensure global food security. Therefore, non-chemical ecofriendly legume GM crops could have great potential for sustainable soil improvement and food grain production by soil salinity reclamation. Considering the above facts, the objective of this review paper is to provide collective information and mechanism through which GM crops could be accessible to soil management and salinity reclamation.

Negative consequences of soil salinity in plants

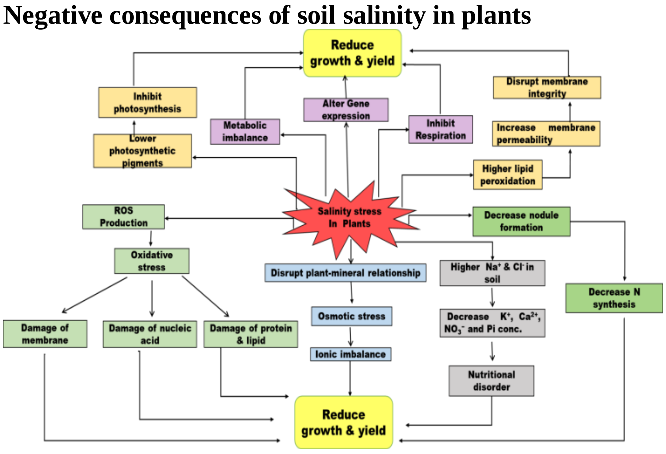

Figure 1. Effects of salinity stress on plants.

Salinity of soil is considered one of the most detrimental abiotic stresses which affect plant morphology, physiology and biochemical metabolism that reduces plant growth and productivity (Malhi *et al.*, 2021; Soltabayeva *et al.*, 2021; Arif *et al.*, 2020). A soil is grouped as under saline stress, when the electrical conductivity (EC) of the soil upsurges with salt concentration and that is when EC reaches $\geq$ 4 dS/m (Almeida *et al.*, 2020). Salinity stress reduces leaf number and leaf area, crop growth and yield through nutrient imbalance, ion toxicity, osmotic imbalance, oxidative stress, reducing photosynthesis, altering gene expression and N-fixation (Desoky *et al.*, 2020; Abdelaal *et al.*, 2020b; Helaly *et al.*, 2017; Hasan *et al.*, 2017; Yan *et al.* 2013). According to Sapre *et al.* (2021) salinity hinders legume crop's growth, development and productivity by disturbing ionic and osmotic balance and hormonal regulation. Root nodule formation of legume plants are adversely affected in salt stress condition, for example- in *Medicago sativa* plants root nodule formation is reduced due to salinity (Saidi *et al.*, 2021). This is reduced N-fixation as nodule formation declined that ultimately severely affected crop productivity under saline stress (Bruning and Rozema, 2013; Noori *et al.*, 2018).

Additionally, Saline soil increases Na^+ concentration and reduces K^+ concentration and increases of Na^+/K^+ ratio that hamper plant growth through ion imbalance (Rasel *et al.* 2020; Rastogi *et al.* 2020). This salinity stress are replaced Ca^{2+} and Mg^{2+} from soil colloids by Na^+, leads to decline of available Ca^{2+} and Mg^{2+} that reduced plant growth (Askari-Khorasgani *et al.*, 2017). Phosphate is precipitated with Ca^{2+} in saline soils that reduces this nutrient uptake (Wang *et al.*, 2021). Furthermore, Plants exposed to salinity stress enhance reactive oxygen species (ROS) formation as by-products that harm cellular components and reduce crop productivity by stimulating osmotic stress (Gupta *et al.*, 2020; Naik & Devaraj, 2016). This generated ROS ($^1O_2$, $OH^\bullet$, H_2O_2, $O_2^{\bullet-}$) are toxic and disrupt plant normal metabolism, increase membrane permeability, damage proteins, DNA/RNA and cell homeostasis (Huihui *et al.*, 2020; Mhadhbi *et al.* 2009; Morton *et al.*, 2019). Due to excessive salt condition, chloroplast grana are disorganized and stacked that compact stomatal density, size and opening in addition to photosynthetic capacity (Zhang *et al.*, 2020). Thus salt stress directed to lesser chlorophyll content, photosynthetic activity, increases ROS contents, and decreases photosystem II activity in *Phaseolus vulgaris* (ElSayed *et al.*, 2021). Moreover, ROS degrade chlorophyll pigments conc. and higher lipid peroxidation, reduction of membrane fluidity with the increase of salinity (Kumar *et al.*, 2020). Loss of chlorophyll and peroxidation of lipid is measured as malondialdehyde (MDA) content, synthesized from lipid peroxidation a considerable indicators for oxidative damage (Pan *et al.*, 2021; Mahmud *et al.*, 2019; Boling *et al.*, 2019). The increased MDA reduced roots and shoots dry matter due to oxidative stress under salinity stress (Musiyenko & Kapinos, 2018). Salt stress reduced relative water contents (RWC), membrane stability index (MSI) and antioxidant enzymatic activities i.e., superoxide dismutase (SOD), peroxidase (POD), ascorbate peroxidase (APX) and catalase (CAT) (Ali *et al.*, 2021 & 2018; Abeer *et al.*, 2015). Thus increased levels of salinity impaired soil structure and the activity of microbe's as well as limit plant growth through detrimental imbalance and metabolic disorders (Sunita, *et al.*, 2020). In *Capsicum annuum* plants- RWC, chlorophyll a and b conc. N, P and K contents and yield considerably reduced in salt-stressed plants (Abdelaal, *et al.*, 2020a). Moreover, electrolyte leakage, lipid peroxidation, superoxide (O_2^-) and H_2O_2 levels, proline, soluble sugars, sucrose, and starch content in addition to Na content significantly improved under salinity conditions (Abdelaal, *et al.*, 2020a). Numerous studies have stated that salt-stressed plants reveal changes to CO_2: O_2 ratio that effects on plants respiratory systems (Jacoby *et al.*, 2013) that largely influenced on the plant's inclusive metabolic homeostasis, particularly in modulating the balance between growth, well-suited solute biosynthesis and energy production (Che-Othman *et al.*, 2020). Expression of genes are also modulated due to salinity stress, for example- *CAT1*, *GR*, *CuZnSOD1*, *APX*, *PrxQ*, and *2-Cys-Prx* genes expression was significantly decreased under salt stress in *Phaseolus vulgaris* (ElSayed *et al.*, 2021). These all modified conditions added more harm to plants and leads to ultimately cell death.

2. Green manure (GM) crops

Crops grown for the purpose of restoring or increasing the organic matter content in the soil are called Green manure crops. Use of Green manure crops in cropping system is called 'Green Manuring'. It is obtained in two ways: by growing green manure crops (in situ) or by collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forest (ex situ). The crops most commonly used for green manuring in Bangladesh are dhaincha (Sesbania aculeata), Dhaincha is an ideal for rice based cropping system (Irin and Biswas, 2020b) and is versatile, drought and flood tolerant green manure crop that can be adapted to varying soil and climatic conditions. Green leaf manure crops may be leguminous or non-leguminous in nature that is incorporate into soil at green succulent stage preferably at 40DAS (Irin and Biswas, 2021a). The most important green manure crops are as follows:

Green manures			
Legumes		**Non-legumes**	
Green manure	**Green manure**	**Green manure**	**Green leaf manure**
Sesbania rostrata	Vigna unguiculata	(eg) Sunflower	(Calotropis
Sesbania aculeata	Vigna radiata	Buck wheat	Adathoda
Crotalaria juncea	clover, lupine, alfalfa		*Thespesia*
Vigna mungo	Leuceana leucocephala		

GM is basically short-day plant and sensitive to photoperiod having short vegetative period when sown in August or September (Singh *et al.*, 1991). GM is grown in April and tilled into the soil and it slowly decomposes and gradually releases these nutrients to the next crop and reduced inorganic fertilizer cost for its subsequent crops by providing organic matter (Irin *et al.*, 2020a; Irin and Biswas, 2020b; Irin and Biswas, 2022). At the same time, green manure serves as a source of food for numerous soil microbes and organisms which are extremely important for soil health.

In *in situ* GM, short-duration (45 to 60 days) crops are grown and incorporated into soil at the same site where in *ex situ* GM, foliage and tender parts of GM crops collected from nearby forests, shrubs, and trees are incorporated into the soil at 15–30 days prior to the sowing of main crops (SSSA 1997). Generally, Sesbania rostrata produced the highest number of leaves followed by Sesbania aculeatea, crotalaria juncea, vigna unguiculata, vigna radiate (Irin and Biswas, 2021a). The legume crops contain nodule for fixing atmospheric N (Rao 2014). GM crop should have some desirable characteristics, viz., fast-growing habit, short duration, high N accumulation rate, high tolerance to biotic stresses (pest and disease), abiotic stresses (flood, drought, salinity, and adverse temperatures), wide range of ecological adaptability, timely release of nutrients, photoperiod insensitivity, high seed production, higher seed viability, and most importantly easiness in incorporation (Meena *et al.*, 2015a; Irin and Biswas, 2021a) stated that *Sesbania* GM showed vigorous growth and more branched compared to *Crotalaria juncea* resulting these plants contain more protein, and rich sources of nitrogen and phosphorus when decomposed. GM, generally legumes contribute higher amount of nitrogen. They fix atmospheric di-nitrogen by symbiosis with rhizobia (Rhizobium, Bradyrhizobium, Sinorhizobium and Mesorhizobium). The legume rhizobium symbiosis compensates 40 percent of worlds fixed Nitrogen (Ladha *et al.*, 1992). Green manure N has long residual effects compared to inorganic fertilizer which help to sustain soil fertility and soil productivity. The biomass and nutrient content of important green manure and green leaf manure crops are mentioned in Table 1 and 2.

Table 1. Biomass production of green manure crops.

Crop	Age (Days)	Dry Biomass (t/ha)	Reference
Sesbania aculeata	45	4.51	**Irin and Biswas 2021a, Irin *et al.*, 2019**
S.rostrata	45	5.12	
Sunnhemp	45	5.25	
Mung bean	45	2.86	
Blackgram	45	2.6	
Cow pea	45	3.1	
Ipil-ipil	45	3.19	
Mimosa	45	2.68	

Table 2. Nutrient content of green manure crops.

Plant	Scientific name	Nutrient content (%) on air dry basis			Reference
		N	P2O5	K	
Sunhemp	*Crotalaria juncea*	2.60	0.60	2.00	**Ramanjaneyulu *et al.*, 2017 Shirale *et al.*, 2018**
Dhaincha	*Sesbania aculeata*	3.30	0.70	1.30	
Sesbania	*Sesbania speciosa*	2.71	0.53	2.21	
	Tephrosia purpurea	4 .00	0.3	0.8	
	Phaseolus trilobus	2.10	0.50	-	
Subabool	Leucaena leucocephala	2.17	0.18	1.31	
Green gram	Vigna radiata	1.67	0.33	1.02	
Cowpea	Vigna unguiculata	2.13	0.25	1.51	

Irin and Biswas (2021a) stated dry biomass production (Table 1) by these legume crops may vary from 2 to 5 t ha^{1} and *Sesbania* spp along with *Crotalaria juncea* produced the highest dry matter. According to Sara (2018), green manure should not till too deep into the soil and is to turn plants maximum 15 centimeters or approximately 6 inches deep because soil microbes are the most active in this upper soil layer and will increased the decomposition process and released nutrients to the soil. Green manure crops should be incorporated at the flowering stage to get lower C/N ratio. The N and C content in roots, shoots, and leaves may also vary. In general, leaves contain lower C/N ratio as compared to stem and roots (Palm *et al.* 1988). Inclusion of legumes in the cropping systems help to save up to 25% to 50% of recommended level of 'N' application to the associated cereal and improve soil 'N' status (Balasubramaniyan and Palaniappan, 2002; Irin and Biswas, 2020b). Different green manuring crops content different amount of nitrogen. N accumulation in major leguminous green manure crops are shown in table 3.

Table 3. N accumulation in major leguminous green manure crops.

Crop	Growth duration (days)	N Accumulation (kg/ha)	Reference
Glycine max	45	115	
Crotalaria juncea	45	169	
Cajanus cajan	45	33	Meelu *et al.*, (1985)
Sesbania aculeate	45	225	
Vigna radiate	45	75	
Dolichos Lablab	45	63	
Indigofera tinctoria	45	45	Furoc *et al.*, (1985)
Sesbania rostrata	56	176	
Sesbania aculeate	56	144	
Vigna unguiculata	45	75	Morris *et al.*, (1986)
Vigna radiate	45	75	
S. rostrata	60	219	Ladha *et al.*, (1988)
S. cannabina	60	171	
S. aculeata	50	28	Irin and Biswas, 2022
S. rostrata	50	26	

3. Green manure for reclamation of salinity

Green manure serves as a source of food for numerous soil microbes and organisms, thus improving the physical properties of soil and subsequent and successive crop growth also enhanced (Sara, 2018; Pung *et al.*, 2004; Irin and Biswas, 2022, Sultani *et al.*, 2007). Saline soils contain large amount of soluble salts i.e. Ca++, Mg++, and Na+ etc (Levy and Shainberg, 2015) in dissolved state in a moist soil or as crystal state in dry soil which restricts plant growth, development, yield, seed quality due to osmotic stress in the root zone (Shirale *et al.*, 2018, Yildiz *et al.*, 2020). Legumes GM have become an important global bio resource not only for N2 fixation (Irin *et al*, 2021b; Maikhuri *et al.*, 2016), but also for reclamation of saline soils (Bruning *et al.*, 2015). The highest number of nodules plant[1] was observed in S. rostrata followed by S. aculeate (Irin and Biswas, 2021a) and plant growth promoting rhizobacteria (PGPR) are potential bioinoculants to enhance crop productivity in saline agriculture (Shultana *et al.*, 2022). The free-living and symbiotic bacteria in nature can fix atmospheric N2 in salt stress conditions and contribute to plant growth (Sultana *et al.*, 2022). Generally, plant root-colonizing microorganisms (e.g., fungi and bacteria) form symbiotic associations with plants to confer tolerance under different stress conditions, such as salinity. N-fixing legumes have an advantages over non leguminous plant for reclaiming saline soils is that the plants remove toxic ions and increase soil-N levels as well. For example, Hedysarum carnosum, a pastoral legume, was able to increase Na+ accumulation in the roots and maintain high symbiotic N2 fixation (SNF) efficiency and subsequent soil-N content under high salinity (100 mM NaCl), (Kouas *et al.*, 2010).

Application of organic amendments in the form of green manures and crop residues reduces pH and ESP of the alkali soils due to production of organic acids and increase in availability of Ca2+ that exchange with Na+ of clay complex leading to creation of favorable environment for microbial activity (Rao and Pathak, 1996, Mahmoodabadi *et al.*, 2013; Tejada & Benítez 2014, Vakeesan &Nishanthan, 2007). Percentage of organic carbon and availability of different nutrients for crop production in saline and alkali soils are reclaimed through green manuring fertilizer.For example, Dhaincha and sunhemp green manures reduces concentration of certain cations and anions such as Cl-, SO42-, HCO3- and CO32-. (Shirale *et al.*, 2018). Effect of green manuring crops for salinity reclamation and crop performance are shown in figure 2.

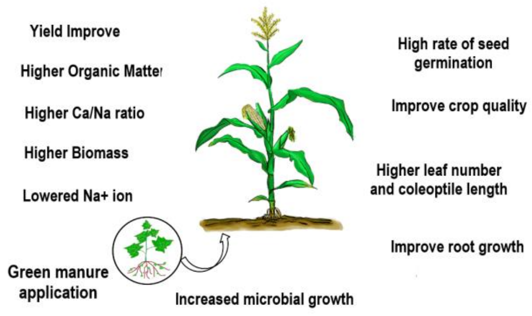

Fig 2. Green manure incorporation mechanism for salinity reclamation.

Among the organic amendments dhaincha was more superior to other organics which reduced ESP by 20.9% and act as promising alternate option for gypsum (Shirale *et al.*, 2017). Effects of different green manures for salinity reclamation are showed in table 4.

Table 4. Effects of different green manures for salinity reclamation.

Green manure	Applied plants	Salinity level	Role of Green manure	Reference
Sebania bispinosa	Gossypium herbaceum	↓	1. Decreased soil salinity and soil Sodicity 2. Increased CEC, ESP available nutrients 3. Improvemed organic carbon and available soil nutrients 4. Increased cotton production.	Parwar *et al.*, 2020
	Triticum aestivum	↓	1. Wheat production was increased 2. Phosphate content was increased in soil.	Qudratullah *et al.*, 2010; Rao and Gill, 2000
	Oryza sativa	↓	1. Increased crop and grain yield 2. Amelioration salinity	Siam *et al.*, 2014
Sesbanaia+ Rye	Zea mays	↓	1. Increased N,P,K and organic matter 2. Increased grain yield	Bai *et al.*, 2017
Green manure + FYM	*Oryza sativa*	↓	1.increased the level of chlorophyll a and total chlorophyll pigments 2.Increased Grain yield	Suriyan and Chalermpol, 2011
Sesbania + Compost + FYM	*Oryza sativa* and Triticum aestivum	↓	Increased rice-wheat production in saline affected area.	Sarwar *et al.*, 2020
Crotalaria juncea	Gossypium herbaceum		1.Decreased soil salinity and soil Sodicity	Parwar et al.(2020)

Green manure	Applied plants	Salinity level	Role of Green manure	Reference
		↓	2.Improved soil properties 3 Increased cotton production.	
Vicia villosa	*Oryza sativa*	↓	1..Reclamed soil salinity	Lee *et al*., 2014
Medicago sativa			Salt tolerant variety	Noble *et al*., 1984
Sesbania+Gypsum	40mMNacl		Increased crop (rice and wheat) yield and reduced salinity	Ghafoor *et al*., 2011
Hedysarum carnosum	100mM NaCl		Increase Na+ accumulation in the roots 2.Increased N-fixation 3.Improved soil fertility	Kouas *et al*., 2010
Acacia nilotica and Leucaena leucophela	90mM NaCl		1.Increased N-fixation	Bruning & Rozema 2013
M. siculus			Salt tolerant annual legume	Countryman, 2017
Vigna marina			Potential for salinity reclamation	Buddenhagen,, 2014
S. carnosa	150mM NaCl		Improved photosynthesis Reclamation salinity Increased N-fixation	Hajer *et al*., 2017
alfalfa (M. sativa L.)			Good salt tolerance Produced highest biomass	El Shaer & Al Dakheel, 2016
sweet clover (M. officinalis)			1.Fixed substantial amounts of N2 in saline soil 2.Reclamation salinity	. Bruning *et al*. 2015
Casuarina equisetifolia	200mM NaCl		Produced highest N in saline soil	Mahmood *et al*., 2008; Bruning *et al*., 2015

Organic amendments lead to elevated CO2 (Yazdanpanah, 2016) and thus produced organic acids which helps in dissolving native CaCO3 (Qadir *et al*., 2007; Mubarak & Nortcliff 2010) resulting into faster removal of exchangeable sodium and accelerate the reclamation of calcareous sodic soil. For example the degree of reclamation potential of different green manures followed the sequence as dhaincha > sunhemp > cowpea > leucaena loppings > green gram (Shirale *et al*., 2017). The released H+ from the breakdown of organic materials goes off into reaction with the salts and carbonates to solubilize them into their component parts (Ontl *et al*., 2021). Again, green biomass reduced the evaporation from soil surface and decreases salt concentration in the root zone which results in arresting sub soil sodicity (Shirale *et al*., 2018)

Conversely, during the mineralization process, organic matter releases humic substances, which may convert soil phosphates into available forms in saline soil and potassium (K) also increases through the increase of CEC linked to organic matter content which is important to maintain the turgor pressure of plant under drought and salinity stress. Green manure ameliorates the salinity by increasing soil ph in saline soil and Sesbania aculeata and Delonix elata are very effective green manures and green leaf manures used for reclamation of saline and sodic soils (Shirale *et al*., 2017, Yazdanpanah & Mahmoodabadi 2013).

Irin *et al*., (2019) reported that Dhaincha green manure produced huge biomass which convert into organic matter after decomposition and rapidly increased soil chemical properties. *Sesbania* spp. (dhaincha) is tolerant to different stress conditions e.g., salinity, water-logging, high and low temperatures, etc. and can be grown in unproductive poor soils for their improvement (Bunma and Balslev 2019). *Sesbania* spp. has been recommended for reclamation of saline and sodic soils because it can withstand with a high electrical conductivity up to 10 mS/cm. (Chavan and Karadge 1986, Ren *et al*., 2019, Sarwar *et al*., 2022). Bai *et al*. (2017) reported that green manuring (sesbania and rye grass) rapidly improved the chemical properties of mudflat saline soil and increasing soil organic carbon and available N and P, which promoted growth of maize. Green manure crop like Sun hemp and Dhanicha crops absorb the salinity through root nodules (Bruning *et al*., 2015) thus potentially increase crop productivity in saline environments (Parwar *et al*., 2020). Incorporating green manure dhaincha in saline soil increases the bioavailability of phosphate in the succeeding crop and yield increased as well (Qudratullah *et al*., 2010, Rao and Gill ,2000). Net-photosynthetic rate (Pn) in the salt-stressed leaves was strongly related to total grain weight, resulting in yield improvement. Suriyan Cha-um and Chalermpol Kirdmanee (2011) reported that green manure mixed with FYM (Farm yard manure) increased the level of chlorophyll a and total chlorophyll pigments in RD6 (Oryza sativa L. spp. indica) rice grown in saline soil (2% salt level).Use of compost, FYM and sesbania is useful for enhancing yield of rice-wheat production grown from salt affected soil environment (Sarwar *et al*., 2020, Awan *et al*., 2015).

Tamarind, Pavetta indica, Thespesia, neem and sunn hemp were also effective against salinity and were used to improve the soil fertility (Vakeesan *et al*., 2008). Some tree species like Eucalyptus camaldlensis, Leucaena leucocephlaand Tamarixa phyla were found suitable for utilization of salt-affected soils but with a little reclamation effect (Qureshi, *et al*., 1993). Apart from producing a good amount of wood, these species reduced soil EC/SAR after 7 years. According to Lee *et al*., (2014) stated that hairy vetch can be use under concentration of 0.1% salinity as green manure for reclaimed saline agriculture and beach pea (Vigna marina), also has the potential to be used for the reclamation of salt-affected areas (Buddenhagen, 2014). The genus Melilotus, Medicago sativais and M. siculus is one of the most salt tolerant and waterlogging tolerant of temperate legumes (Rogers *et al*. 2008) and still grows at 250 mM NaCl (Noble *et al*. 1984). Also, tree legumes such as Acacia nilotica and Leucaena leucophela have been grown as fodder under saline conditions with slight reduction in symbiotic nitrogen fixing efficiency at 90 mM NaCl (Bruning & Rozema 2013). Bruning *et al*. (2015) stated that, symbiotic N fixation persists under relatively high salt concentrations (at least one-quarter sea water strength) and this suggests legumes can serve as a green manure in a saline agricultural system. This improves the sustainable character already associated with saline agriculture.

4. Conclusion

Reclamation of salinity stress through organic amendments will enhances food security and healthy environment for soil. Leguminous green manuring has the capacity to a higher N content and lower C/N ratio, easily decomposable and released nutrient at a faster rate and also reduced the N immobilization risk for succeeding crops. After decomposition, green manuring crops replace exchangeable sodium with calcium and bring about a reduction in soil pH, thereby enhancing nutrient uptake, and improve soil health in order to obtain a better crop production. Use of green manure crops may have a better chance than farm yard manure of being successfully integrated into a soil reclamation management package. This review has shown and suggested the function of leguminous green manuring crops for salinity reclamation is an environmentally friendly and more economical to improve soil fertility and crop production in saline-affected areas. In the future, extensive field based research needs to be emphasized to find out suitable salt tolerant green manuring crops in the salt affected area.

Author contribution

Irin I.J conducted to the conceptualization and reviewed of the article. Irin I.J. NH and AH carried out data and resource collection for manuscript preparation. Irin ,I.J NH,AH, and MA edited the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

There is no conflict of interest.

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