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A STUDY ON MANAGING COASTAL SALT-AFFECTED SOIL TO INCREASE SOIL FERTILITY AND MEDICINAL PLANT PRODUCTIVITY

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Abstract

Soil fertility restrictions, such as high pH and salinity, reduce productivity in coastal areas because they alter the solubility, availability, and efficiency of plant nutrients. The physical and biological features of soil are profoundly impacted by salinity and nutrient deficits. Coastal farmers are among of the worlds poorest because of inadequate soil management and natural calamities like tsunamis, cyclones, and floods. The creation of alternative crops for areas that are salt-affected or water-logged has received widespread interest in recent years. A commodity-based strategy and towards an alternative agricultural system approach is crucial for achieving efficient and sustainable agriculture. Research into novel production systems, such as the use of medicinal plants as an alternative cropping system, that may boost the coastal farming community's economy should be prioritized in light of the paradigm shift.

Keywords: *Managing, Coastal, Salt-Affected, Soil Fertility, Medicinal Plant.*

1. Introduction

Various soil fertility restrictions reduce crop growth and production in coastal salt impacted soils, resulting in poor productivity. Soil degradation and changes in plant nutrient solubility, availability, and efficiency are side effects of soils with high salt content and/or high pH. Salt has a devastating effect on the soil microorganisms and enzyme activity. Due to natural disasters like tsunamis, cyclones, and floods, as well as bad agricultural practices, coastal farmers are living in abject poverty. In recent years, scientists throughout the world have been working to improve salt-affected and water-logged crop production. According to the Indian Council of Agricultural Research's (ICAR) 2020 vision, moving away from a commodity-based strategy and towards an alternative agricultural system approach is crucial for achieving efficient and sustainable agriculture. With this change in thinking comes the need to create a new production system, one that makes full use of the natural resources indigenous to the area and, for example, incorporates the use of medicinal herbs. Research on alternative agricultural systems that have the potential to enhance the economic circumstances of the farming community in coastal regions should be prioritized. [1-3]

Approximately one billion people, mostly in developed countries, use therapeutic plants. There has been a dramatic growth in the use of botanical food supplements during the last several decades. Medicinal plants are widely used all around the world because of the substances and phytochemicals they contain. Eighty percent of the population in developing countries may use traditional medicine, according to some estimates.[4-5]

The past two decades have seen a meteoric rise in demand around the globe for herbal items including medicines and aromatic oils. India has a lot to offer in the medicinal plant trade because to its long history with herbs, extensive biodiversity, technological prowess, and low labour costs. India is home to around 45,000 plant species, 15,000 of which are utilized in traditional medicine. Unique weather patterns, significant rainfall, a wide variety of soil types, and the prevalence of different farming techniques all lend themselves favourably to the cultivation of a range of medicinal plants in India's coastal ecology. Mangroves, salt dunes, salt marshes, and sandy coasts are just few of the coastal ecosystems that are home to medicinal plants.[6-7]

2. Literature review

Aflatuni, A., (2020) Several biological processes need phosphorus (P). Adenosine triphosphate is a component of many different molecules, including nucleic acid, phospholipids, coenzymes, DNA, NADP, and, of course, ATP. There aren't too many metabolic pathways essential to healthy development that this doesn't contribute to in some way. Coenzymes involved in the creation of proteins from amino acids are also activated. In addition to helping seeds germinate, P also encourages early development, root growth, blooming, bud set, fruiting, and maturity.[8]

Aggarwal, P.K., (2019) The decomposition of organic matter creates humic acid, a naturally occurring polymeric organic molecule that may be found in soil, peat, and lignites. It has the potential to be utilised as a fertiliser replacement and boost agricultural output. Plants may benefit from humic acid (HA) because it enhances nutrient absorption and has hormonal effects. Vegetables, roots, flowers, and grains have all had their yields boosted by humic compounds, according to some research. As a factor in enhancing soil's physical qualities, it boosts tilth, aeration, and moisture retention. Its greater cation exchange capability allows it to continue performing its chemical role. As its biological role is shown, humic acid serves as a carbon source for nitrogen-fixing bacteria. Plants fed humic substances (HS) have been demonstrated in several studies to exhibit improved root, leaf, and shoot development, as well as increased fruit output.[9]

Ajit Singh and B.K. Kapali, (2018) The soil structure and microbial populations are improved by the addition of humic substances (HS). Stevenson (1994) showed that plants absorb humic acid via their roots, convert it, and it may even affect plant metabolism. Humic acid (HA) treatment at 1280 ppm boosted root growth, whereas HA addition at 200 ppm boosted dry matter production. It has been shown that humic substances (HS) help plants expand their root systems, take in more nutrients, produce more fruit, germinate more seeds, and increase their photosynthesis. This motivates the proposal of HS as a means to boost agricultural output.[10]

Badiyala, D. and K.S. Panwar, (2017) In order to boost nutrient availability, biofertilizers are added to seed, soil, or compost to improve the diversity and activity of beneficial microbes and the rate at which certain microbial activities occur. Effective strains of nitrogen-fixing, phosphate-solubilizing, and cellulolytic microorganisms may be included in these formulations as either active or dormant cells. The usage of biofertilizers has enhanced yields while decreasing the need for chemical fertilisers. Plants treated with azospirillum have been shown to enhance their yield by 5-20 percent while using just 40 percent of the required amount of nitrogen. In addition to fixing nitrogen through nitrogenase, Azospirillum also produces growth hormones such Indole acetic acid, Gibbreralic acid, and Cytokinin. [11]

S. Chandrasekaran and R. Govindasamy. (2016). Soil is the unconsolidated organic and mineral substances on Earth's surface that develops through time as a result of the combined actions of several genetic and environmental variables, including as macro- and microorganisms, temperature, and topography, on parent materials. Many chemical, physical, and morphological aspects of soil are determined by the parent material. Chemical, physical, ecological, and morphological differences exist amongst soil horizons. Erosion, pollution, salinization and alkalinity, climate change and deterioration, and degradation all pose problems for soil and its production. Soil supplements such gypsum, press mud compost potassium humate charcoal and nanomaterials, in addition to microbiological methods and Geographic Information System (GIS) techniques, are often used in the management of salt-affected soils.[12]

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3. Methodology

A research was undertaken on the management of coastal salt impacted soils to boost fertility and crop yields for medicinal plants by the Department of Soil Science and Agriculture Chemistry at Annamalai University in Annamalai Nagar, Tamil Nadu. The effects of organic manure and bio-resources on the soil fertility and production of medicinal plants in a coastal setting were evaluated in two different pot trials for each crop. In order to assess the efficacy of pot studies in real-world situations, farmers conducted two sets of field tests, one with Catharanthus roseus. The specifics of the current investigation's pot and field tests, soil and plant sample collection, documented observations made during the crop's development period, and analytical procedures used.

Crop: Catharanthus roseus Patented cancer and hypotensive drugs are derived in large part from the elegant and upright perennial plant Catharanthus roseus (L.) G. Don, also known as the Madagascar periwinkle. It's one of the few plants used medicinally that has a history of serving many functions, including as a diuretic, an antidysentric, a hemostatic, and an antiseptic. The diabetic, menstruating, and stung by a wasp all benefit from its leaves. The therapeutic properties of the flowering stem are due to its abundance of active ingredients, including alkaloids, tannins, saponins, pectin, and organic pigments. Catharanthus roseus's yield is very sensitive to the availability and distribution of certain nutrients, especially nitrogen, phosphorus, and potassium.

3.1 Experimental soil

Pot tests used soil taken from a farmer's field at Theethapalayam, C. Mutlur, a seaside hamlet near Chidambaram in the Cuddalore District of Tamilnadu, India. The soil used in the experiment was sandy.

3.2 Preparation of soil samples

The obtained soil samples were allowed to air dry in the shade, lightly malleted to fit through a 2 mm sieve, and properly combined before being put to use in pot tests.

3.3 Organics used in the present investigations

- Fertilizer Yeast Media (FYM)
- Biofertilizer

- Humic acid isolation from lignite
- Use Catharanthus roseus as a test subject.

Pot Experiment I

Annamalai University's Department of Soil Science and Agricultural Chemistry conducted a pot experiment in the pot culture yard using the Catharanthus roseus variety with rose-purple flowers from July 2018 to May 2019 to learn more about the plant's nutrient, phosphorus, and potassium (NPK) requirements in coastal sandy soil.

Experimental details

Soil : Coastal sand

Crop : Catharanthus roseus cv. rose –purple flowerDesign : CompletelyRandomizedDesignReplication: 4

Treatments

T_1	:	Absolute Control (without NPK application)
T_2	:	10:20:20kgN:P_2O_5:K_2Oha^{-1}
T_3	:	20:30:30kgN:P_2O_5:K_2Oha^{-1}
T_4	:	30:40:40kgN:P_2O_5:K_2Oha^{-1}
T_5	:	40:50:50kgN:P_2O_5:K_2Oha^{-1}

Forty kilogrammes of sand from the shore was gathered and cleaned up, then put into a one-foot-tall cement container. Urea, super phosphate, and muriate of potash were administered at the prescribed rates per acre in accordance with the treatment plan for Catharanthus roseus, which required a certain ratio of these nutrients. Half of the nitrogen was sprayed at the beginning of the vegetative stage and the other half was administered when the flowers began to form.

Pot Experiment II

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Coastal soils are notoriously poor in physical and exchange characteristics and nutrient availability due to their low organic matter content. Poor nutrient retention makes applied nutrients vulnerable to leaching. The physical, chemical, and biological qualities of such soil would all improve considerably by the addition of organic manure. This led us to conduct a pot experiment from July 2009 to May 2010 using a variety of chosen NPK and organic manures and bio-resources to determine the effect that manure has on soil fertility.

Experimental details

Soil : Coastal sand

Crop : Catharanthus roseus cv. rose –purple
flower Design: Completely Randomized

Design Replication: 4

Forty kilogrammes of sand from the shore was gathered and screened before being put into one-foot-tall cement containers. The soil was amended with the proper amounts of FYM (12.5 t ha-1) and biofertilizers (2000 g ha-1 of Azospirillum and 2000 g ha-1 of Phosphobacteria). Soil pH was adjusted by applying a solution of humic acid powder dissolved in 0.01 N potassium hydroxide.

3.4 Statistical analysis

Results from both laboratory and field tests were examined statistically. The crucial difference was calculated at a 5% probability threshold for statistical significance. AGRES Software was used for the statistical analysis of the experimental data.

4. Results

Throughout the coastal areas of Tamil Nadu, rice is often grown as a single crop. The coastal region's varying agroclimate and soil conditions make it ideal for growing medicinal plants. Poor crop production is a direct outcome of soil problems such as salinity, alkalinity, coarse texture, and nutrient depletion. As a result, farmers that diversify their operations by cultivating medicinal plants stand to gain a substantial financial advantage. Thus, a number of pot and field studies were conducted employing Catharanthus roseus to increase soil fertility and medicinal plant yield in coastal salt damaged soil.

4.1. Pot experiment – I

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From July 2018 to May 2019, the Department of Soil Science and Agricultural Chemistry conducted a pot experiment - I to determine the nutrient, phosphorus, and potassium (NPK) needs of Catharanthus roseus in coastal sandy soil.

4.1.1 Effect of different levels of NPK on the growth and yield of Catharanthus roseus

The various NPK concentrations had a notable effect on the final plant height. Treatments T4 and T5 both scored better than the control group in terms of plant height at 120, 210, and 300 days after transplanting compared to the other NPK levels tested. The plant height at 300 DAT was 70.40 cm for the treatment T5, 40:50:50 kg NPK ha-1, and 70.94 cm for the treatment T4, 30:40:40 kg NPK ha-1. The control group consistently recorded the shortest plant growth.

At 120, 210, and 300 DAT, the number of branches per plant was considerably higher when NPK was applied. Application of NPK at 30:40:40 kg ha-1, T4, and 40:50:50 kg ha-1, T5, were similarly effective in achieving a greater number of branches per plant than the other NPK levels. T4 and T5 treatments resulted in 10.52 and 10.45 branches per plant, respectively, during harvest. Fewer branches were found in the control group.

Table 4.1: Periwinkle [Catharanthus roseus (L.)] height in a container experiment as a function of nitrogen, phosphorus, and potassium

Treatments	Plant height (cm)		
	120DAT	**210DAT**	**300DAT**
T_1– Control	39.92	47.36	52.24
T_2-10:20:20kgNPKha^{-1}	46.74	52.25	60.15
T_3-20:30:30kgNPKha^{-1}	48.18	53.50	63.02
T_4-30:40:40kgNPKha^{-1}	52.96	58.72	70.94
T_5-40:50:50kgNPKha^{-1}	52.88	58.06	70.40
SEd	**1.19**	**1.53**	**1.81**
CD(p=0.05)	**2.40**	**3.07**	**3.64**

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Table 4.2: Periwinkle [Catharanthus roseus (L.)] branching in a pot experiment: effect of nitrogen, phosphorus, and potassium levels

Treatments	Numberof branchesplant^{-1}		
	120DAT	**210DAT**	**300DAT**
T_1– Control	2.18	4.25	6.64
T_2-10:20:20kgNPKha^{-1}	3.73	6.45	8.56
T_3-20:30:30kgNPKha^{-1}	3.97	6.84	9.02
T_4-30:40:40kgNPKha^{-1}	4.65	7.80	10.52
T_5-40:50:50kgNPKha^{-1}	4.50	7.66	10.45
SEd	**0.21**	**0.30**	**0.37**
CD(p=0.05)	**0.43**	**0.61**	**0.74**

The current investigation provided substantial evidence that different concentrations of NPK fertilizers significantly influenced the growth of plant leaves.

The maximum total number of leaves was seen in the T4 therapy, regardless of the NPK level (129.50 at 120 days after transplant, 107.05 at 210 days after transplant, and 93.00 at 300 days after transplant). This, however, was on par with the T5 treatment's 127.25, 105.75, and 92.75 after 120, 210, and 300 days after transplant. The control group had the fewest leaves of any of the NPK treatments.

Table 4.3: Periwinkle [Catharanthus roseus (L.)] leaf production in response to varying NPK concentrations in a container experiment-I

Treatments	Numberof leavesplant^{-1}		
	120DAT	**210DAT**	**300DAT**
T_1- Control	92.00	65.50	52.50
T_2-10:20:20kgNPKha^{-1}	111.25	91.50	80.25
T_3-20:30:30kgNPKha^{-1}	116.75	96.05	84.50
T_4-30:40:40kgNPKha^{-1}	129.50	107.05	93.00

T_5-40:50:50kgNPKha^{-1}	127.25	105.75	92.75
SEd	**3.65**	**3.04**	**2.62**
CD(p=0.05)	**7.34**	**6.12**	**5.27**

Table 4.4: Per plant dry leaf yield in a pot experiment with periwinkle [Catharanthus roseus (L.)] as affected by nutrient, phosphorus, and potassium (NPK) levels

Treatments	**Dry leaf yield plant^{-1}(g)**		
	120DAT	**210DAT**	**300DAT**
T_1- Control	2.24	1.56	1.35
T_2-10:20:20kgNPKha^{-1}	3.66	2.03	1.72
T_3-20:30:30kgNPKha^{-1}	3.78	2.12	1.85
T_4-30:40:40kgNPKha^{-1}	4.13	2.88	2.56
T_5-40:50:50kgNPKha^{-1}	4.09	2.75	2.50
SEd	**0.11**	**0.10**	**0.09**
CD(p=0.05)	**0.23**	**0.21**	**0.18**

Plant-1 dry leaf yield was highly responsive to the treatments. Dry leaf yield was greatest for treatment T4 (4.13 g on 120 DAT, 2.88 g on 210 DAT, and 2.56 g on 300 DAT). It measured 4.09, 2.75, and 2.50 g per plant, which is on par with T5. The dry leaf yield was also considerably affected by the other NPK concentrations when compared to the control. Dry leaf yield plant-1 in the treatment (T1) was lowest at 120, 210, and 300 DAT, with values of 2.24, 1.56, and 1.35 g plant-1, respectively.

The total dry leaf yield per plant (g) was considerably impacted by the varied NPK concentrations. Up to 30:40:40 kg NPK ha-1 (T4), Catharanthus roseus showed a response to NPK fertiliser. T4 had the greatest total dry leaf yield at 9.57 g plant-1, while T5 had the lowest at 9.34 g plant-1. The next two highest yields were from T3 (7.63 g plant-1) and T2 (7.41 g plant-1). Treatment 1 (T1) resulted in the lowest dry leaf yield per plant, at 5.15 g.

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Table 4.5:Periwinkle [Catharanthus roseus (L.)] dry leaf yield affected by nitrogen, phosphorus, and potassium (NPK) levels in container experiment-I

Treatments	Total dry leaf yieldplant^{-1}(g)	Dry leaf yield(gpot $^{-1}$)
T_1– Control	5.15	21.96
T_2-10:20:20kgNPKha^{-1}	7.41	30.43
T_3-20:30:30kgNPKha^{-1}	7.63	32.24
T_4-30:40:40kgNPKha^{-1}	9.57	39.66
T_5-40:50:50kgNPKha^{-1}	9.34	38.92
SEd	**0.34**	**1.02**
CD(p=0.05)	**0.68**	**2.06**

Catharanthus roseus' nitrogen content was significantly impacted by the amount of NPK fertiliser used.

The maximum N content was found throughout all development stages when NPK was applied at a rate of 30:40:40 kg ha-1. This treatment resulted in a 1.20 percent N content in roots and a 1.62 percent N content in shoots at harvest. Both the root and the shoot nitrogen concentration at harvest were 1.19 percent, which was consistent with NPK application of 40:50:50 kg ha-1. The lowest N content was found in the T1 treatment, at 0.99% in the roots and 1.373% in the shoots.

Table 4.6:Nitrogen content of Catharanthus roseus (L.) root and shoot as a function of nutrient (NPK) levels in container experiment-I

Treatments	Ncontentofroot(%)			Ncontentofshoot(%)		
	120 DAT	210 DAT	300 DAT	120 DAT	210 DAT	300 DAT
T_1- Control	0.93	1.07	0.99	1.29	1.42	1.37
T_2-10:20:20kgNPKha^{-1}	1.09	1.18	1.13	1.40	1.57	1.52
T_3-20:30:30kg NPKha^{-1}	1.10	1.20	1.14	1.44	1.60	1.54

T_4-30:40:40kg NPKha^{-1}	1.15	1.27	1.20	1.50	1.66	1.62
T_5-40:50:50kg NPKha^{-1}	1.14	1.25	1.19	1.49	1.65	1.60
SEd	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**
CD(p= 0.05)	**0.02**	**0.02**	**0.03**	**0.02**	**0.02**	**0.04**

4.2. Pot experiment – II

A second pot experiment was conducted utilising organic manures and bioresources with chosen NPK treatments from pot experiment - I to enhance the fertility of coastal sandy soil and boost the productivity using Catharanthus roseus as the test crop. The outcomes are shown in the table below.

Catharanthus roseus showed signs of enhanced growth after being fertilised with organic matter and bio-resources in coastal sand. Treatment 4 (T4), which included the application of 75% NPK + FYM @ 12.5 t ha -1 + HA @ 20 kg ha-1, resulted in the maximum plant growth. In general, the average height was 64.16 inches at 120 days after birth (DAT), 75.18 inches at 210 days, and 99.64 inches at 300 days. However, with 100% NPK + FYM @ 12.5 t ha-1 + HA @ 20 kg ha-1 (T2), the crop reached a height of 62.91, 73.26, and 98.22 cm at the same pivotal phases. The third treatment (T3) consisted of 100% NPK plus BF at 2 kg ha-1 plus HA at 20 kg ha-1, and the fifth treatment (T5) consisted of 75% NPK plus BF at 2 kg ha-1 plus HA at 20 kg ha-1.

At 120, 210, and 300 DAT, the number of branches per plant was considerably greater in all treatment groups compared to the control. At 120, 210, and 300 DAT, T4 had the highest recorded number of branches per plant, although it was otherwise comparable to T2. T4 and T2 treatments saw 13.62 and 13.18 number of branches at 300 DAT, respectively. Both T3 and T5 resulted in a greater average number of branches per plant than the control condition (which had the fewest).

Table 4.7: The growth of Catharanthus roseus (L.) in a pot experiment: II. The effects of nitrogen, phosphorus, and potassium fertilizers and organic manures and bio-resources

	Plant height(cm)

Treatments	120 DAT	210 DAT	300 DAT
T_1 – 100% NPK	45.09	53.66	72.85
T_2–100%NPK+FYM@12.5tha^{-1}+HA@20kgha^{-1}	62.91	73.26	98.22
T_3 – 100% NPK + BF @ 2 kg ha^{-1}+ HA @ 20 kgha^{-1}	56.29	68.37	90.12
T_4 – 75% NPK + FYM@12.5 t ha^{-1}+ HA @ 20kg ha^{-1}	64.16	75.18	99.64
T_5– 75% NPK + BF @ 2 kg ha^{-1}+HA @ 20 kg ha^{-1}	55.66	66.65	87.43
T_6– 50% NPK + FYM@12.5 t ha^{-1} + HA @ 20kg ha^{-1}	50.97	61.16	81.37
T_7 – 50% NPK + BF @ 2 kg ha^{-1}+HA @ 20 kg ha^{-1}	50.48	60.48	80.74
SEd	**1.70**	**1.90**	**2.53**
CD (p =0.05)	**3.42**	**3.82**	**5.08**

Table 4.8: Periwinkle [Catharanthus roseus (L.)] branching in a pot experiment with different levels of nitrogen, phosphorus, and potassium as well as organic manures and bio-resources

Treatments	Number of branchesplant $^{-1}$		
	120 DAT	210 DAT	300 DAT
T_1 – 100% NPK	3.64	5.83	7.11
T_2–100%NPK+FYM@12.5tha^{-1}+HA@20kgha^{-1}	5.07	8.36	13.18
T_3 – 100% NPK + BF @ 2 kg ha^{-1}+ HA @ 20 kgha^{-1}	4.71	7.70	11.09
T_4 – 75% NPK + FYM@12.5 t ha^{-1}+ HA @ 20kg ha^{-1}	5.18	8.64	13.62
T_5– 75% NPK + BF @ 2 kg ha^{-1}+HA @ 20 kg ha^{-1}	4.53	7.42	10.72
T_6– 50% NPK + FYM@12.5 t ha^{-1} + HA @ 20kg ha^{-1}	4.63	7.02	9.47
T_7 – 50% NPK + BF @ 2 kg ha^{-1}+HA @ 20 kg ha^{-1}	4.55	6.86	9.26
SEd	**0.12**	**0.29**	**0.38**
CD (p =0.05)	**0.24**	**0.58**	**0.76**

5. Conclusion

The medicinal crop Catharanthus roseus were grown in coastal salt affected soil, and the effects of chemical fertilizer mixed with different organics and bio resources on soil parameters and crop growth and yield were investigated. According to the results of the studies conducted with Catharanthus roseus, the growth, yield, nutrient absorption, and NPK availability in soil were all significantly enhanced by the application of NPK in combination with organic manures and bioresources. Out of all the treatments, 75% NPK + FYM @ 12.5 t ha-1 + humic acid @ 20 kg ha-1 had the best results for Catharanthus roseus in terms of growth, yield, and yield characteristics. Dry leaf yield increased by 58.66 percent and root yield increased by 57.80 percent as compared to the control group.

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