CURRICULUM VITAE

Dr UMESH PANKAJ
H.No.1376, Dhyanchand Colony,
Premganj, Sipri Bazar, Jhansi-284003, Uttar Pradesh, India
Mob.:**09415178652**/07905052295
E-mail.: umeshpankaj55@gmail.com; umeshpankaj55@hotmail.com

OBJECTIVE:

- To acquire a position where I get the appropriate exposure to upgrade my skills and enhance my Professional skills that can contribute in organization growth by taking active decision.
- To become successfully professional and to work in an innovative and competitive environment to do productive hard work.

ACADEMIC CREDETIALS :

S. No.	Exam Passed	School/ Board /University	Year	% Marks	Division
1.	Intermediate (12^{th})	S.G.N.K. Inter College, Jhansi /U.P. Board	2004	58.00	2^{nd}
2.	B.Sc. (H) Microbiology	Bundelkhand University, Jhansi(U.P.)	2005-08	60.23	1^{st}
3.	M.Sc. Applied Microbiology & Biotechnology	University Teaching Department/ Dr. H. S. Gour University, Sagar (M.P.)	2010	63.17	1^{st}
4.	M. Phil. Environmental Science	Bundelkhand University, Jhansi(U.P.)	2011	70.00	1^{st}
5.	Ph.D. Life Science (Microbiology)	CSIR-CIMAP-JNU, New Delhi	Awarded on 10-01-2018		
6.	National Eligibility Test for Lecturership (NET) Agricultural Microbiology	ASRB (ICAR), New Delhi	2014	-	-
7.	UGC-NET Environmental Science	UGC-New Delhi	2012	-	-

Title of Ph.D. thesis: *Study of the Mycorrhizal symbiosis with Palmarosa (Cymbopogon martinii) under salt affected soil and its influence on growth, yield, quality and soil properties*

Other qualifications:

- Six month dissertation (M.Sc.) in Soil Microbiology; complete from Indian Institute of Soil Science, ICAR Bhopal, M.P.
- Six month dissertation (M.Phil.) in Environmental Microbiology; completed from Department of Microbiology, Bundelkhand University, Jhansi
- Three months (Jan.–March 2015) course on **"Application of remote sensing and GIS for natural resources"** sponsored by National Natural Resources Management System (NNRMS), Indian Institute of Remote Sensing. **ISRO** Dept. of Space, Govt. of India
- Computer office automation digital art & designing.

- Computer Foundation Course (2005-06).
- Project work/ Industrial Training at **Sanchi Dairy Gwalior**, M.P.

Award and honors

1. **Young Microbiologist Award-2018** by Agro-Environmental Development Society in International Conference on Emerging Issues in Agricultural, Environmental & Applied Sciences for Sustainable Development at Sam Higginbottom Uni. of Agriculture, Allahabad (UP)

2. **Best poster award** "K. Khan, A.K. Gupta, **Umesh Pankaj,** R.K. Verma (2017) Essential oil bearing aromatic plants for sequestering carbon in marginal soils, In: "Nation seminar on Healthy Soil for Healthy Life" organized by ICAR-Indian Institute of Sugarcane Research, Lucknow, 5 Dec.

Research Experiences

- 5 months research experience as Project Assistant at CSIR-CIMAP, Lucknow (U.P.)
- 1 year and 6 months of Post-doc experience (March 2018 to Sep 2019) at CSIR-IHBT, Palampur (H.P.) in the project "Development of Microbial formulation to serve as stress buster and bio-fertilizer for improving crop productivity in stress agriculture".

Membership of scientific bodies

- Life Member of "The Association of Microbiologist of India (AMI)" Memb. No. (**4340-2016**)
- Life Member of "Indian Science Congress Association (ISCA)" Memb. No. (**L29031**)
- Life Member of "Agro-Environmental development Society (AEDS)" Memb. No. (**174/2019**)

Research Publication:

1. G. Singh, **Umesh Pankaj,** P.V. Ajayakumar, R.K. Verma **(2019)** Phytoremediation of sewage sludge by *Cymbopogon martinii* (Roxb.) Wats. var. motia Burk. grown under soil amended with varying levels of sewage sludge. *International J of Phytoremediation* (Online). (**ISSN:** 1522-6514, **IF 2.237**) https://doi.org/10.1080/15226514.2019.1687422

2. G. Singh, **Umesh Pankaj,** C. Chand, R.K. Verma (**2019**) Arbuscular Mycorrhizal Fungi-Assisted Phytoextraction of Toxic Metals by *Zea mays* L. From Tannery Sludge. *Soil and Sediment Contamination: An International Journal,* 28(8):729–746. (**ISSN:** 1532-0383, **IF 0.992)** https://doi.org/10.1080/15320383.2019.1657381

3. Umesh Pankaj*, G. Singh, R.K. Verma (**2019**) Microbial Approaches in Management and Restoration of Marginal Lands. In: (**Eds**.) Jay Shanker Singh, "*New and Future Developments in Microbial Biotechnology and Bioengineering: Microbes in Soil, Crop and Environmental Sustainability*". Elsevier, US. pp. 295–305. (**ISBN:** 9780128182581; Published: July 2019) https://doi.org/10.1016/B978-0-12-818258-1.00020-0

4. Umesh Pankaj, D.N. Singh, G. Singh, R.K. Verma (**2019**) Microbial inoculants assisted growth of *Chrysopogon zizanioides* promotes phytoremediation of salt affected soil. *Indian J. of*

Microbiology, 59(2):137–146. (**ISSN:** 0973-7715, **IF 1.533**) *https://doi.org/10.1007/s12088-018-00776-9*

5. Umesh Pankaj, R.S. Verma, Anju Yadav, R.K. Verma (**2019**) Effect of arbuscular mycorrhizae species on essential oil yield and chemical composition of commercially grown palmarosa (*Cymbopogon martinii*) varieties in salinity stress soil. *Journal of Essential Oil Research,* 31(2):145–153. (**ISSN:** 1041-2905, **IF 1.233**) *doi.org/10.1080/10412905.2018.1512533*

6. Umesh Pankaj, D.N. Singh, P. Mishra, P. Gaur, C.S. Vivekbabu, K. Shanker, R.K. Verma (**2018**) Autochthonous halotolerant plant growth promoting rhizobacteria promote bacoside A yield of *Bacopa monnieri* (L) Nash and phytoextraction of salt-affected soil. *Pedosphere* (**Accepted**, **ISSN:** 1002-0160, **IF 3.188**)

7. Umesh Pankaj, S.K. Verma, S. Semwal, R.K. Verma (**2017**) Assessment of natural mycorrhizal colonization and soil fertility status of lemongrass [(*Cymbopogon flexuosus*, Nees ex Steud) W. Watson] crop in subtropical India. *Journal of Applied Research on Medicinal and Aromatic Plants*, 5:41–46. (**ISSN:** 2214-7861, **IF 1.966)** *http://dx.doi.org/10.1016/j.jarmap.2016.10.002*

8. T. Damodaran, V.K. Mishra, S.K. Jha, **Umesh Pankaj**, G. Gupta, R. Gopal (**2019**) Identification of rhizosphere bacterial diversity with promising salt tolerance, PGP traits and their exploitation for seed germination enhancement in sodic soil. *Agricultural Research*, 8(1):36–43. (**ISSN:** 2249-7218) *https://doi.org/10.1007/s40003-018-0343-5*

9. P. Trivedi, K. Singh, **Umesh Pankaj**, S.K. Verma, R.K. Verma, D.D. Patra (**2017**) Effect of organic amendments and microbial application on sodic soil properties and growth of an aromatic crop. *Ecological Engineering*, 102:127–136. (**ISSN:** 0925-8574, **IF 3.406)** *http://dx.doi.org/10.1016/j.ecoleng.2017.01.046*

10. S.K. Verma, **Umesh Pankaj,** K. Khan, R. Singh, R.K. Verma (**2016**) Bio-inoculants and Vermicompost Improve *Ocimum basilicum* Yield and Soil Health in a Sustainable Production System. *Clean – Soil, Air, Water*, 44 (9999):1– 8. (**ISSN:** 1863-0669, **IF 1.338)** *DOI: 10.1002/clen.201400639*

11. K. Khan, **Umesh Pankaj**, S.K. Verma, A.K. Gupta, R.P. Singh, R.K. Verma (**2015**) Bio-inoculants and vermicompost influence on yield, quality of *Andrographis paniculata*, and soil properties. *Industrial Crops and Products*, 70: 404–409. (**ISSN:** 0926-6690, **IF 4.191**) *http://dx.doi.org/10.1016/j.indcrop.2015.03.066*

12. R.K. Verma, S.K. Verma, **Umesh Pankaj**, A.K. Gupta, K. Khan, K. Shankar (**2015**) Improvement in the yield and quality of Kalmegh (*Andrographis paniculata* Nees) under the sustainable production system. *Natural Product Research*, 29(3): 297–300. (**ISSN:** 1478-6419, **IF 1.928**) *http://dx.doi.org/10.1080/14786419.2014.971791*

__Communicated Book chapter__

1. Umesh Pankaj[*] (**2020**). Multifarious benefits of biochar application in different soil types. Eds. C. Singh, “Biochar in Agricultural and Environmental Management”. *Springer Nature*, New York. (*Under review*)

2. Umesh Pankaj* (**2019**). Bio-fertilizers for management of soil, crop and human health. Eds. C. Singh, "Microbes as biofertilizers in agricultural fields". *CRC Press, Taylor & Francis Group*.

3. Umesh Pankaj* and R.K. Verma **(2019).** Phytoremediation of salt affected soil using medicinal and aromatic crops intervention with arbuscular mycorrhizal fungi. *Springer Nature,* New York

4. Umesh Pankaj* and R.K. Verma **(2020).** Role of Microbial secondary metabolites in plant growth and nutrient cycle regulation under abiotic stress soil. *Springer Nature*, Heidelberg, Germany

Paper presented in conferences:

1. K. Khan, A. K. Gupta, **Umesh Pankaj** and R.K. Verma (2017) Essential oil bearing aromatic plants for sequestering carbon in marginal soils: A review. "Nation seminar on Healthy Soil for Healthy Life" organized by ICAR-Indian Institute of Sugarcane Research, Lucknow, 5 Dec. pp 14–23.

2. K. Ramesh, **Umesh Pankaj**, Sujan S. Kushwah (2010) Nanoporous Materials (Zeolites) in Agricultural Management-Indian Results. "II National conference on Advanced Materials (processing, characterisation and application)" organized by Centre for Scientific and applied Research, PSN College of Engineering and Technology, Tirunelveli (Tamil Nadu), 25-27 Aug. pp 23-25.

3. Oral Presentation on "**AMF affects the essential oil quality and yield of *Anethum graveolens*"** in symposium **"JIGYASA-2015"** organized by CSIR-CIMAP, Lucknow.

Conference proceeding Abstracts (Poster):

International

1. Attended the International Conference on "Recent Advances in Agricultural, Environmental & Applied Sciences for Global Development (RAAEASGD-2019)" at Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh on 27-29 Sep. 2019.
2. **Umesh Pankaj**, G. Singh, R. Kumar, R.K. Verma (2017) Restoration of salt-affected soil by *Chrysopogon zizanioides* alliance with bio-inoculants and vermicompost. **In souvenir:** 58th Annual Conference of Association of Microbiologist of India-2017 & International Symposium on Microbes for Sustainable Development: Scope & Applications (MSDSA-2017)" organized by Babasaheb Bhimrao Ambedkar University, Lucknow on Nov. 16-19. pp.150.
3. **Umesh Pankaj**, S.K. Verma, D. Vashisth, R.K. Gupta, R.K. Verma, A.K. Shasany (2015) Effect of soil moisture levels on yield and quality of *Artemisia annua*. **In souvenir:** International conf. On medicinal plants: Resource for affordable new generation healthcare. pp.52.
4. S.K. Verma, **Umesh Pankaj**, P. Trivedi, K. Khan, R.S. Verma, R.K. Verma (2015) Effect of Ocimum cultivation on the weed community structure and diversity in proceeding crops. **In souvenir**: International conf. On medicinal plants: Resource for affordable new generation healthcare. pp.51.
5. **Umesh Pankaj**, Rishi K. Saxena (2011) Isolation and Characterization of Microorganisms inhabiting the roots of *Eichhornia crassipes* from Laxmital Jhansi, Bundelkhand. **In souvenir**: International Conference on Microorganisms in Environmental Management and Biotechnology" organized by Department of Biotechnology and Bioinformatics Centre, Barkatullah University Bhopal, (M.P).

National

1. **Umesh Pankaj**, G. Singh, R.K. Verma (2017) Effect of halotolerant bio-inoculants and different fertilizers on the growth of Palmarosa (*Cymbopogon martinii*) under salt affected soil. **In souvenir:** "Nation seminar on Healthy Soil for Healthy Life" organized by ICAR-Indian Institute of Sugarcane Research, Lucknow, 5 Dec.105-106.
2. **Umesh Pankaj**, M. Semwal, H.S. Chauhan, R.K. Verma (2014) Ashwagandha (*Withania somnifera*) cultivation can provide quality produce and improve economic status of the farmers. Vigyan Bhawan, New Delhi) organised by Council for Development of Rural Areas.
3. P. Trivedi, **Umesh Pankaj,** G. Singh, D.D. Patra, R. K. Verma (2014) Utilization of salt affected soil for the cultivation of aromatic crops to contribute an innovative framework for the development of cropping land. **In souvenir**: National convention and seminar on leveraging aromatic and medicinal plants and product (LAMP), MAPSI CSIR-CIMAP, Lucknow. pp.11.
4. K. Khan, A. K. Gupta, S. K. Verma, **Umesh Pankaj,** R. K. Verma (2014) Carbon sequestration study of aromatic plants based cropping systems. **In souvenir**: National convention and seminar on leveraging aromatic and medicinal plants and product (LAMP), MAPSI CSIR-CIMAP, Lucknow. pp.49.
5. **Umesh Pankaj,** G. Singh, P. Trivedi, S. Singh, R.K. Verma (2013) Change the AMF colonization, microbial population and nutrients status in the rhizosphers of lemongrass crop (*Cymbopogon flexuosus*) in three subsequent cropping years. National conference on Microbes Promoting crop Health and sustainability Organized by CSIR-CIMAP, CSIR-NBRI-Lucknow.
6. Participated in "Rashtriya Vaigyanik Sangoshthi–Krishi, Urja and Swasthaya ke Vikas me Vigyan ke Navintam Aayam" organized by BARC-CSIR-CIMAP on 01-06 November, 2015 at CIMAP, Lucknow.

Volunteer

1. As a core organising committee member "**JIGYASA-2017**" organized by CSIR-CIMAP, Lucknow.
2. As a volunteer in symposium **"JIGYASA-2015"** organized by CSIR-CIMAP, Lucknow.
3. As a volunteer in symposium **"JIGYASA-2014"** organized by CSIR-CIMAP, Lucknow.

Workshop Attained

1. Workshop on Bioinformatics: Knowledge discovery in biology, 2011. Organized by Department of Microbiology, Bundelkhand University, Jhansi.

Co-Curricular Activities:

- Participated in cricket tournament in school level.
- Elected as CSIR-CIMAP-Mahak Staff Club Member and served for 5 years.
- Committee member for organizing "CSIR-Husain Zaheer Memorial Bridge Tournament-2016".
- Volunteer and committee member for organizing "CSIR-SSBMT-Indoor Games-2017".

Techniques Known:

- Routine microbiological techniques, Molecular identification of microbial strains, Plant superoxide dismutase, plant proline activity and chlorophyll content.
- Soil Parameters- pH, electrical conductivity, cation exchange capacity, sodium adsorption ratio, exchangeable sodium percentage, Soil enzymes such as dehydrogenase, alkaline and acid phosphatase activity, Soil Nutrient analysis (N, P, K, etc.), Soil organic carbon, Soil microbial biomass carbon etc.
- Arbuscular Mycorrhizal Fungi detection in plant roots and soil.
- Bioreactor handling and PGPR formulation preparation (liquid and solid).

Personal Details:

Name	:	**Dr UMESH PANKAJ**
Date of Birth	:	01-Aug-1987
Father's name	:	Mr. Babu Ram Pankaj
Mother's name	:	Mrs. Vaijanti Devi
Gender	:	Male
Marital Status	:	Single
Religion	:	Hindu
Nationality	:	Indian

References : **1.** Dr Rajesh Kumar Verma, Principal Scientist (Ph.D. supervisor)
Division of Agronomy and Soil Science
CSIR-CIMAP, Lucknow-226015
M. No. **+91 8004941063**, Email.: **rajeshcimap@rediffmail.com**

2. Dr Aparna Maitra Pati, Senior Principal Science
Division of Biotechnology, CSIR-IHBT, Palampur-176061
M.No. **+91 9816024955,** Email.: aparna@ihbt.res.in

3. Dr DD Patra, Vice-chancellor & Former Chief Scientist
Bidhan Chandra Krishi Vishwavidhyalaya, Mohanpur, Dist-Nadia-741252, W.B.
M. No**. +91 9450096944**, Email**.: ddpatra@rediffmail.com**

DECLARATION

I hereby declared that all statements made in this resume sheet are true, correct & complete to the best of my knowledge & belief.

Place: Delhi
Date: 11/01/2020 (UMESH PANKAJ)

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ORIGINAL RESEARCH ARTICLE

Microbial Inoculants Assisted Growth of *Chrysopogon zizanioides* Promotes Phytoremediation of Salt Affected Soil

Umesh Pankaj[1] · Durgesh Narain Singh[2] · Geetu Singh[1] · Rajesh Kumar Verma[1]

Received: 19 July 2018 / Accepted: 21 December 2018 / Published online: 7 February 2019

Abstract Restoration of salt-affected soil through cultivation *Chrysopogon zizanioides* is a promising approach. The two way benefit of such an approach is that reclamation of salt-affected soil concomitant to improve plant growth and increased yield of essential oil produced in the plants roots. Earlier studies showed physiological changes and reduced growth of *C. zizanioides* under salinity. In the present study, plant growth promoting microorganisms viz. *Pseudomonas monteilii*, *Bacillus megaterium*, *Azotobacter chroococcum* and *Rhizophagus intraradices* were used as bio-inoculants for cultivation of *C. zizanioides* under salt-affected soil. Bio-inoculants in combination with vermicompost significantly increased the growth and productivity of *C. zizanioides* under salt-affected soil, and simultaneously improved soil health. When compared to control, the soil physico-chemical and biological properties of bio-inoculants treated plants was significantly improved. The reclamation of salt-affected soil was evident by the significant decrease in the level of soil pH (11.0%), electrical conductivity (23.5%), sodium adsorption ratio (15.3%), and exchangeable sodium percent (12.4%) of bio-inoculants treated plants. The improvement of soil cation exchange capacity indicated the decrease in soil salinity. Whereas increase in the microbial count (four-fold), AMF spores (447 spores), dehydrogenase (six-fold), acid (two-fold) and alkaline phosphatase (five-fold) activities in rhizosphere soil of bio-inoculant treated plants indicated the improved biological properties. A positive correlation of plant biomass production to soil organic carbon, total Kjeldahl nitrogen, available phosphorus and cation exchange capacity depicted improved nutrients content in rhizosphere soil of bio-inoculant treated plants. The findings of this study suggest that *P. monteilii* and *R. intraradices* with vermicompost can be effectively used as bio-inoculants for encouragement of phytoremediation in salt-affected soil.

Keywords Microbial inoculants · Phytoremediation · Plant growth · *Chrysopogon zizanioides* · Salt-affected soil

Introduction

Salt-affected soils are widespread in arid and semi-arid regions and occupy approximately 3.0% of total geographical area of world. The extensive agricultural practices with poor irrigation system and climatic changes had lead to increase in the percentage of salt-affected soil [1]. About 402 million hectare (Mha) area is classified as saline soil and 434 Mha land has been categorized as sodic soil [1]. These type of soils are characterized by high soil pH, electrical conductivity, sodium concentration (high exchangeable sodium percent and sodium absorption ratio) and least organic carbon [2, 3]. Soil salinization and sodication alters the physico-chemical and biological properties of the soil [1]. Excessive salts in soil decreases water

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s12088-018-00776-9) contains supplementary material, which is available to authorized users.

Geetu Singh: AcSIR-CIMAP PhD student

✉ Rajesh Kumar Verma
rajeshcimap@rediffmail.com

1 Department of Soil Science, CSIR-Central Institute of Medicinal and Aromatic Plants, Kukrail Picnic Spot Road, Lucknow 226015, India

2 Laboratory of Synthetic Biology, Division of Biotechnology, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow 226015, India

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Effect of arbuscular mycorrhizae species on essential oil yield and chemical composition of palmarosa (*Cymbopogon martinii*) varieties grown under salinity stress soil

Umesh Pankaj[a,b], Ram Swaroop Verma[c], Anju Yadav[c] and Rajesh Kumar Verma[b]

[a]CSIR-CIMAP-JNU Ph. D. (UGC-RGNF) Fellow, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow, India; [b]Department of Soil Science, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow, India; [c]Chemical Sciences Division, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow, India

ABSTRACT

This study was framed to assess the essential oil yield and quality of four varieties of palmarosa (*Cymbopogon martinii* (Roxb.) Wats. var. *motia* Burk, viz. Trishna, Tripta, PRC-1 and CIMAP-Harsh under the salt affected soil with intervention of arbuscular mycorrhizal fungi (AMF). The essential oil yield (7.04–12.70 g kg^{-1} fresh biomass) and geraniol yield (5.71–10.56 g kg^{-1} fresh biomass) were significantly affected by the variety, soil type and AMF inoculation. Altogether, twenty-eight constituents, representing 96.90–99.43% of the total oil compositions were identified using Gas chromatography (GC)-flame ionisation detection and GC-mass spectrometry techniques. Major constituents of the oils of different varieties were geraniol (76.73–83.28%), geranyl acetate (6.60–13.06%), linalool (0.90–3.00%), (2*E*,6*Z*)-farnesol (0.80–3.00%), geranial (0.30–2.03%), myrcene (0.54–2.00%), (*E*)-*β*-ocimene (0.43–1.95%), (*E*)-caryophyllene (0.30–1.30%) and geranyl hexanoate (0.31–1.20%). Significantly higher essential oil and geraniol yields were observed in var. Tripta due to AMF intervention (*Funneliformis mosseae* and *Glomus aggregatum*).

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KEYWORDS
Cymbopogon martinii; palmarosa; salt affected soil; AMF inoculation; geraniol yield; essential oil composition

Introduction

Palmarosa (*Cymbopogon martinii* (Roxb.) Wats. var. *motia* Burk., belongs to family Poaceae, is an important perennial, essential oil-bearing crop, native to India. India is the principal producer and exporter of palmarosa oil and its products to the world market (1). In India, the oil is produced mainly in Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka and Andhra Pradesh (2). During 2009–2010, about 44 tonnes of palmarosa oil was exported to nineteen different countries, including the United States, France and the Philippines (3). The essential oil isolated from the freshly harvested or partially dried flowering shoot biomass is used mainly for the extraction of high-quality geraniol, which is used in high-grade perfumes, cosmetics, flavour and pharmaceutical industries (1,4). The oil is reported to be an excellent extender in all floral, rose-like perfumes. The olfactory note of geraniol from palmarosa oil is considered superior to the geraniol prepared from other sources (2). However, the quality of palmarosa essential oil depends on various factors, including location of growing (2,5), growth stage (6–8), plant part (2) and nutrients stresses (9).

The production and quality of medicinal and aromatic plant-derived products are influenced by both biotic and abiotic factors. Salinity is one of the main abiotic factors, which negatively affects the plant production all over the world (10). Increasing salt concentrations in the soil decreases the plant ability to grow and develop (11). In this respect, the use of a non-hazardous biological method, such as mycorrhizal fungi applications, and use of moderately salt-tolerant plants are the excellent choices to mitigate the negative effects of salinity stress (12). Among the biotic factors, arbuscular mycorrhizal fungi (AMF) are undoubtedly a vital factor of the soil and their impact on the yield and sustainable agricultural systems has been largely documented (13). Under natural conditions, approximately 90% of plant species form a symbiotic association with AMF (14). They benefit from the carbon provided by the host plants and have numerous beneficial effects on the plants, including enhanced nutrient uptake, plant growth and resistance to abiotic stresses (15–17). Therefore, the strategies for controlling soil salinity stress through enhancing nutrient uptake and water use efficiency can be accomplished with appropriate

CONTACT Rajesh Kumar Verma rajeshcimap@rediffmail.com

Decision Letter (pedos201708404.R2)

From: pedospheareadm@issas.ac.cn
To: rajeshcimap@rediffmail.com
CC:
Subject: Pedosphere - Decision on Manuscript ID pedos201708404.R2
Body: Re.: Autochthonous halotolerant plant growth promoting rhizobacteria promote bacoside A yield of Bacopa monnieri (L) Nash and phytoextraction of salt-affected soil

Dear Dr. Verma:

It is a pleasure to accept your manuscript entitled "Autochthonous halotolerant plant growth promoting rhizobacteria promote bacoside A yield of Bacopa monnieri (L) Nash and phytoextraction of salt-affected soil" for publication in Pedosphere. You will receive an edited version before preparation of proofs.

Thank you for your fine contribution. On behalf of the Editors of Pedosphere, we look forward to your continued contributions to the Journal.

Sincerely,

Editorial Office, Pedosphere
2018-01-10

Date Sent: 14-Mar-2018

Autochthonous halotolerant plant growth promoting rhizobacteria promote bacoside A yield of *Bacopa monnieri* (L) Nash and phytoextraction of salt-affected soil

Umesh Pankaj[1], Durgesh Narain Singh[2], Pooja Mishra[3], Pooja Gaur[4], C. S. Vivek Babu[5], Karuna Shanker[4] and Rajesh Kumar Verma[1]

[1]Department of Soil Science, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow-226015, India

[2]Division of Biotechnology, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow-226015, India

[3]Division of Microbial Technology, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow-226015, India

[4]Analytical Chemistry Department, CSIR-Central Institute of medicinal and Aromatic Plants, Lucknow-India

[5]CSIR-Central Institute of medicinal and Aromatic Plants, research centre Bangalore, India

[*]**Corresponding author:** Dr. Rajesh Kumar Verma
Department of Soil Science,
CSIR-Central Institute of Medicinal and Aromatic Plants,
Lucknow-226015, India.
Phone (Office): 0522-2718513, Fax: 0522-2342666
Email: rajeshcimap@rediffmail.com

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Effect of organic amendments and microbial application on sodic soil properties and growth of an aromatic crop

Pragya Trivedi, Kripal Singh *, Umesh Pankaj, Sanjeet Kumar Verma, Rajesh Kumar Verma , D.D. Patra

Division of Agronomy and Soil Science, CSIR-Central Institute of Aromatic and Medicinal Plants, Picnic Spot Road, Lucknow 226015, Uttar Pradesh, India

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Microbial inoculation
Salt-affected soils
Sludge
Soil enzymes

ABSTRACT

In this experiment, we studied the effects of microbial inoculation, vermicompost and sludge application on physical, chemical and microbial properties of sodic soil and growth of *Ocimum basilicum* (holy basil). Sodic soil collected from natural field was amended with two bacterial strains A and C (isolated from the same soil), vermicompost and tannery sludge @ 5 t ha^{-1} upto 0–15 cm soil depth of field buried cement barrels (125 cm height, 49.5 cm diameter) in such a way that nine treatments (control sodic soil (T_0), vermicompost or VC (T_1), VC + strain A (T_2), VC + strain C (T_3), VC + strain A and C (T_4), tannery sludge or TS (T_5), TS + strain A (T_6), TS + strain C (T_7), and TS + strain A and C (T_8) were formed. After application of these treatments, soil was incubated for one month at constant moisture. After one month of incubation period, 35 days old seedlings of *O. basilicum* were planted in barrels. Significant changes in soil properties (physico-chemical, microbial and enzyme activities), due to application of microbes and organic amendments, were observed after one month of incubation (AIS) and at crop harvest (ACH). On an average soil pH, electrical conductivity (EC), exchangeable sodium (Na), soil microbial biomass carbon (SMBC), soil microbial biomass nitrogen (SMBN), soil respiration (SR), microbial quotient (C_{mic}:C_{org}), and metabolic quotient (qCO_2) were significantly higher in incubated soils than crop harvested soils. Study concludes that use of vermicompost, sludge and microbial inoculants increase soil fertility and enhance yield and oil quality of *Ocimum basilicum*. Furthermore, incubation for one month before crop plantation was sufficient time for amendments to facilitate changes in sodic soil properties.

1. Introduction

Soil degradation resulting from salinity and sodicity is a major environmental constraint with severe negative effects on soil fertility and agricultural productivity in arid and semiarid regions of the world (Lambers, 2003; Young et al., 2015). Sodic soils suffer from high level of pH (>8.5), exchangeable sodium percentage (ESP) >15, sodium adsorption ratio (SAR) >15 (US Salinity Laboratory Staff, 1954) and low fertility (Wong et al., 2010). An excess amount of exchangeable sodium in sodic soil reverses the process of aggregation and causes soil aggregates to disperse into their constituent individual soil particles (Sumner, 1993) and makes soil physically unfit (Nelson et al., 1998; Fig. 1). The structural imbalance of soil particle causes damage to microbial cells, their activities and in turn nutrient availability (Singh, 2015). An important step toward the reclamation of sodic soils is the identification of suitable amendments tools. For this purpose, physical method (Choudhury et al., 2014; Ganjegunte et al., 2014; Singh et al., 2016a) and chemical (gypsum) (Sadiq et al., 2007; Sahin et al., 2011), organic (farm yard manure, crop residues, leaf litters and industrial effluents) (Tejada et al., 2006; Dendooven et al., 2010; Singh et al., 2016b; Oo et al., 2015) and biological (afforestation, Plant Growth Promoting Rhizobacteria and Mycorrhyza) (García and Mendoza, 2007; Singh et al., 2013a; Wu et al., 2014; Singh et al., 2015) amendments have been used. In recent studies attention has been turned to study the impact of these amendments on soil microbial activities (Tejada et al., 2006; Yuan et al., 2007) and use of microbes or microbial consortia (Sahin et al., 2011; Paikray and Singh, 2011; Ashraf et al., 2013) for reclamation of salt-affected soils. Understanding the changes in soil fertility, crop productivity and microbial activities due to use of microbial consortia along with industrial wastes can provide an empirical solution for sodic soils.

* Corresponding author. Present address: Distant Research Centre, CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow 226001, Uttar Pradesh, India.

E-mail addresses: pragyatrivedi89@gmail.com (P. Trivedi), kripalsingh04@gmail.com (K. Singh), rajesh.verma@cimap.res.in (R.K. Verma), ddpatra@rediffmail.com (D.D. Patra).

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Bio-inoculants and vermicompost influence on yield, quality of *Andrographis paniculata*, and soil properties

Khushboo Khan, Umesh Pankaj, Sanjeet K Verma, Anand K Gupta, Raksh Pal Singh, Rajesh Kumar Verma*

CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow 226015, India

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ABSTRACT

Andrographis paniculata is a source of diterpenoids and 2′-oxygenated flavonoids, which are of utility in pharmaceutical industry and ayurvedic formulations. With the aim of producing quality herb, an experiment was conducted with different combinations of bio-inoculants and vermicompost (VC) in controlled condition. It was observed that the highest Leaf:Stem (L:S) ratio, fresh herb yield and andrographolide yield (0.82, 300 g pot^{-1} and 29.8 g kg^{-1} dry herb, respectively) was recorded when the soil was incorporated with VC along with *Azotobacter chrococcum* (T_3). Further there was a significant improvement in all soil fertility parameters. However, when all the bio-inoculants (*A. chrococcum* + *Bacillus megaterium* + *Pseudomonas monteilii* + *Glomus intraradices*) were mixed with VC, there was a significant improvement in soil dehydrogenase, alkaline, and acidic phosphatase activity. A positive correlation coefficient ($p < 0.01$) could be derived amongst plant growth, yield and soil properties ($r = 0.45–0.85$). The study suggests that application of the bio-inoculants and organic fertilizers can enhance productivity while maintaining the desired quality of the herb.

1. Introduction

Andrographis paniculata (Burm. f.) Wall. ex Nees, commonly known as "King of Bitters" has been used since ancient times as fresh and dried leaves and juice. *A. paniculata* has been widely used as liver tonic, antipyretic, antithrombogenic, blood purifier, hepatoprotective, febrifuge, in jaundice, and digestive disorders (Okhuarobo et al., 2014; Pharmacopoeia, 1955). The plant is native to south eastern Asia and is considered as a wonder drug in traditional Siddha and Ayurvedic systems of medicine and tribal's for multiple clinical applications.

It is extensively cultivated in India, China, Thailand, West Indies, and Mauritius (Kumar et al., 2011). Literature analysis indicates a wide spectrum of pharmacological activities beside its use in commercially available formulations. India, the total collection from wild growing sources is about 5×10^3 MT $year^{-1}$ (Kumar and Kumar, 2013). However, the total kalmegh production (volume) through commercial cultivation is not exactly available in the literature. Due to its high demand, the herb is collected indiscriminately from the wild sources causing decline in the natural availability as well supply to the industry (Raina et al., 2013). The situation entails encouragement of the organic cultivation technology for the production of quality material curtailing excessive use of synthetic fertilizers and chemicals. Further, bio-inoculants add nutrients to the rhizosphere by natural processes like solubilising phosphorus (P) by phosphate solubilising bacteria (PSB) and arbuscular micorrhizal fungi (AMF), stimulating plant growth by providing growth promoting substances by plant growth promoting rhizobacteria (PGPR), fixing atmospheric nitrogen to plant available pools either by free living N fixers (Diazotrophs) or by symbiotic N fixers (Rhizobium) (Andrade et al., 2013; Pěsakoviíc et al., 2013). The use of vermicompost can be utilized as plant growth media or soil conditioner (Edwards and Arancon, 2004). The response of application of bio-inoculants such as free living nitrogen fixing bacteria, plant growth promoting bacteria, and arbuscular mycorrhizal fungi (AMF) for improving growth, yield and usefulness for suppressing diseases of medicinal plants has also been studied (Singh et al., 2009, 2012a,b,c; Awasthi et al., 2011). The objective of the present study was to apply plant nutrients through biological sources (vermicompost and biofertilizers viz., free living nitrogen fixer, PSB, PGPR, and AMF) which are eco-friendly and free of synthetic chemicals.

* Corresponding author. Tel.: +91 5222718513; fax: +91 5222342666.
E-mail address: rajesh.verma@cimap.res.in (R.K. Verma).

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