

Print ISSN : 0972-8813
e-ISSN : 2582-2780

[Vol. 19(3), September-December, 2021]

Pantnagar Journal of Research

(Formerly International Journal of Basic and
Applied Agricultural Research ISSN : 2349-8765)



G.B. Pant University of Agriculture & Technology, Pantnagar



ADVISORYBOARD

Patron

Dr. Tej Partap, Vice-Chancellor, G.B. Pant University of Agriculture and Technology, Pantnagar, India

Members

Dr. A. S. Nain, Ph.D., Director Research, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. A. K. Sharma, Ph.D., Director, Extension Education, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. S. K. Kashyap, Ph.D., Dean, College of Agriculture, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. N. S. Jadon, Ph.D., Dean, College of Veterinary & Animal Sciences, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. K. P. Raverkar, Ph.D., Dean, College of Post Graduate Studies, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. Sandeep Arora, Ph.D., Dean, College of Basic Sciences & Humanities, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. Alaknanda Ashok, Ph.D., Dean, College of Technology, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. Alka Goel, Ph.D., Dean, College of Home Science, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. R. S. Chauhan, Ph.D., Dean, College of Fisheries, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. R. S. Jadaun, Ph.D., Dean, College of Agribusiness Management, G.B. Pant University of Agri. & Tech., Pantnagar, India

EDITORIALBOARD

Members

Prof. A. K. Misra, Ph.D., Chairman, Agricultural Scientists Recruitment Board, Krishi Anusandhan Bhavan I, New Delhi, India
Dr. Anand Shukla, Director, Reefberry Foodex Pvt. Ltd., Veraval, Gujarat, India
Dr. Anil Kumar, Ph.D., Director, Education, Rani Lakshmi Bai Central Agricultural University, Jhansi, India
Dr. Ashok K. Mishra, Ph.D., Kemper and Ethel Marley Foundation Chair, W P Carey Business School, Arizona State University, U.S.A
Dr. B. B. Singh, Ph.D., Visiting Professor and Senior Fellow, Dept. of Soil and Crop Sciences and Borlaug Institute for International Agriculture, Texas A&M University, U.S.A.
Prof. Binod Kumar Kanaujia, Ph.D., Professor, School of Computational and Integrative Sciences, Jawahar Lal Nehru University, New Delhi, India
Dr. D. Ratna Kumari, Ph.D., Associate Dean, College of Community / Home Science, PJTSAU, Hyderabad, India
Dr. Deepak Pant, Ph.D., Separation and Conversion Technology, Flemish Institute for Technological Research (VITO), Belgium
Dr. Desirazu N. Rao, Ph.D., Professor, Department of Biochemistry, Indian Institute of Science, Bangalore, India
Dr. G. K. Garg, Ph.D., Dean (Retired), College of Basic Sciences & Humanities, G.B. Pant University of Agric. & Tech., Pantnagar, India
Dr. Humnath Bhandari, Ph.D., IRRI Representative for Bangladesh, Agricultural Economist, Agrifood Policy Platform, Philippines
Dr. Indu S Sawant, Ph.D., Director, ICAR - National Research Centre for Grapes, Pune, India
Dr. Kuldeep Singh, Ph.D., Director, ICAR - National Bureau of Plant Genetic Resources, New Delhi, India
Dr. M. P. Pandey, Ph.D., Ex. Vice Chancellor, BAU, Ranchi & IGKV, Raipur and Director General, IAT, Allahabad, India
Dr. Martin Mortimer, Ph.D., Professor, The Centre of Excellence for Sustainable Food Systems, University of Liverpool, United Kingdom
Dr. Muneshwar Singh, Ph.D., Project Coordinator AICRP- LTFE, ICAR - Indian Institute of Soil Science, Bhopal, India
Prof. Omkar, Ph.D., Professor, Department of Zoology, University of Lucknow, India
Dr. P. C. Srivastav, Ph.D., Professor, Department of Soil Science, G.B. Pant University of Agriculture and Technology, Pantnagar, India
Dr. Prashant Srivastava, Ph.D., Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, University of South Australia, Australia
Dr. Puneet Srivastava, Ph.D., Director, Water Resources Center, Butler-Cunningham Eminent Scholar, Professor, Biosystems Engineering, Auburn University, U.S.A.
Dr. R. C. Chaudhary, Ph.D., Chairman, Participatory Rural Development Foundation, Gorakhpur, India
Dr. R. K. Singh, Ph.D., Director & Vice Chancellor, ICAR-Indian Veterinary Research Institute, Izatnagar, U.P., India
Prof. Ramesh Kanwar, Ph.D., Charles F. Curtiss Distinguished Professor of Water Resources Engineering, Iowa State University, U.S.A.
Dr. S. N. Maurya, Ph.D., Professor (Retired), Department of Gynecology & Obstetrics, G.B. Pant University of Agric. & Tech., Pantnagar, India
Dr. Sham S. Goyal, Ph.D., Professor (Retired), Faculty of Agriculture and Environmental Sciences, University of California, Davis, U.S.A.
Prof. Umesh Varshney, Ph.D., Professor, Department of Microbiology and Cell Biology, Indian Institute of Science, Bangalore, India
Prof. V. D. Sharma, Ph.D., Dean Academics, SAI Group of Institutions, Dehradun, India
Dr. V. K. Singh, Ph.D., Head, Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi, India
Dr. Vijay P. Singh, Ph.D., Distinguished Professor, Caroline and William N. Lehrer Distinguished Chair in Water Engineering, Department of Biological Agricultural Engineering, Texas A&M University, U.S.A.
Dr. Vinay Mehrotra, Ph.D., President, Vinlax Canada Inc., Canada

Editor-in-Chief

Dr. Manoranjan Dutta, Head Crop Improvement Division (Retd.), National Bureau of Plant Genetic Resources, New Delhi, India

Managing Editor

Dr. S. N. Tiwari, Ph.D., Professor, Department of Entomology, G.B. Pant University of Agriculture and Technology, Pantnagar, India

Assistant Managing Editor

Dr. Jyotsna Yadav, Ph.D., Research Editor, Directorate of Research, G.B. Pant University of Agriculture and Technology, Pantnagar, India

Technical Manager

Dr. S. D. Samantray, Ph.D., Professor, Department of Computer Science and Engineering, G.B. Pant University of Agriculture and Technology, Pantnagar, India

PANTNAGAR JOURNAL OF RESEARCH

Vol. 19(3)

September-December, 2021

CONTENTS

Unrevealing the role of epistasis through Triple Test Cross in Indian mustard NARENDER SINGH, USHA PANT, NEHA DAHIYA, SHARAD PANDEY, A. K. PANDEY and SAMEER CHATURVEDI	330
Testing of InfoCrop model to optimize farm resources for mustard crop under tarai region of Uttarakhand MANISHA TAMTA, RAVI KIRAN, ANIL SHUKLA, A. S. NAIN and RAJEEV RANJAN	335
<i>In vitro</i> evaluation of endophytes and consortium for their plant growth promoting activities on rice seeds DAS, J., DEVI, R.K.T. and BARUAH, J.J.	342
Effect of subsurface placement of vermicompost manure on growth and yield of wheat (<i>Triticum aestivum</i> L. Var. UP 2526) ABHISHEK KUMAR and JAYANT SINGH	348
Assessment of different nutrient management approaches for grain yield, gluten content and net income of common bread wheat (<i>Triticum aestivum</i> L.) in Western Himalayan region of Uttarakhand BHAWANA RANA and HIMANSHU VERMA	359
Suitability assessment of land resources for cassava (<i>Manihot esculenta</i> L.) and yam (<i>Dioscorea spp</i> L.) cultivation in Khana LGA, Rivers State, Southern Nigeria PETER, K.D., UMWENI, A.S. and BAKARE, A.O.	367
Biophysical and biochemical characters conferring resistance against pod borers in pigeonpea PARUL DOBHAL, R. P. MAURYA, PARUL SUYAL and S.K. VERMA	375
Population dynamics of major insect pest fauna and their natural enemies in Soybean SUDHA MATHPAL, NEETA GAUR, RASHMI JOSHI and KAMAL KISHOR	385
Fumigant toxicity of some essential oils and their combinations against <i>Rhizopertha dominica</i> (Fabricius) and <i>Sitophilus oryzae</i> (Linnaeus) NIDHI TEWARI and S. N. TIWARI	389
Long term efficacy of some essential oils against <i>Rhizopertha dominica</i> (Fabricius) and <i>Sitophilus oryzae</i> (Linnaeus) NIDHI TEWARI and S. N. TIWARI	400
Management strategies under chemicals, liquid organic amendments and plant extracts against black scurf of potato caused by <i>Rhizoctonia solani</i> Kühn in tarai regions of Uttarakhand SURAJ ADHIKARI, SHAILBALA SHARMA, R. P. SINGH, SUNITA T. PANDEY and VIVEK SINGH	408
Effective management strategies against ginger rhizome rot caused by <i>Fusarium solani</i> by the application of chemicals, bioagents and Herbal <i>Kunapajala</i> in mid hills of Uttarakhand SONAM BHATT, LAXMI RAWAT and T. S. BISHT	417

Distribution and morphological characterisation of isolates of <i>Fusarium moniliforme</i> fsp. <i>subglutinans</i> causing Pokkah Boeng disease of sugarcane in different sugarcane growing areas of Udham Singh Nagar district of Uttarakhand HINA KAUSAR, BHAGYASHREE BHATT and GEETA SHARMA	429
Biointensive management of <i>Meloidogyne enterolobii</i> in tomato under glasshouse conditions SHUBHAM KUMAR, ROOPALI SHARMA, SATYA KUMAR and BHUPESH CHANDRA KABDWAL	435
Effect of pre-harvest application of eco-friendly chemicals and fruit bagging on yield and fruit quality of mango KIRAN KOTHIYAL, A. K. SINGH, K. P. SINGH and PRATIBHA	447
A valid and reliable nutrition knowledge questionnaire: an aid to assess the nutrition friendliness of schools of Dehradun, Uttarakhand EKTA BELWAL, ARCHANA KUSHWAHA, SARITA SRIVASTAVA, C.S. CHOPRA and ANIL KUMAR SHUKLA	452
Potential of common leaves of India as a source of Leaf Protein Concentrate RUSHDA ANAM MALIK, SHAYANI BOSE, ANURADHA DUTTA, DEEPA JOSHI, NIVEDITA, N.C. SHAHI, RAMAN MANOHARLAL and G.V.S. SAIPRASAD	460
Job strain and muscle fatigue in small scale unorganized agri enterprises DEEPA VINAY, SEEMA KWATRA, SUNEETA SHARMA and KANCHAN SHILLA	466
Drudgery reduction of farm women involved in weeding of soybean crop SHALINI CHAKRABORTY	475
Childhood obesity and its association with hypertension among school-going children of Dehradun, Uttarakhand EKTA BELWAL, K. UMA DEVI and APARNA KUNA	482
Spring water and its quality assessment for drinking purpose: A review SURABHI CHAND, H.J. PRASAD and JYOTHI PRASAD	489
Spatial distribution of water quality for Indo-Gangetic alluvial plain using Q-GIS SONALI KUMARA, VINOD KUMAR and ARVIND SINGH TOMAR	497
Application of geospatial techniques in morphometric analysis of sub-watersheds of Nanak Sagar Catchment AISHWARYA AWARI, DHEERAJ KUMAR, PANKAJ KUMAR, R. P. SINGH and YOGENDRA KUMAR	505
Evaluation of selected carbon sources in biofloc production and carps growth performance HAZIQ QAYOOM LONE, ASHUTOSH MISHRA, HEMA TEWARI, R.N. RAM and N.N. PANDEY	516
Calcium phosphate nanoparticles: a potential vaccine adjuvant YASHPAL SINGH and MUMTESH KUMAR SAXENA	523
Factors affecting some economic traits in Sahiwal Cattle DEVESH SINGH, C. B. SINGH, SHIVE KUMAR, B.N. SHAHI, BALVIR SINGH KHADDA, S. B. BHARDWAJ and SHIWANSHU TIWARI	528
The effect of probiotics and growth stimulants on growth performance of Murrah Buffalo SAMEER PANDEY, RAJ KUMAR, D.S. SAHU, SHIWANSHU TIWARI, PAWAN KUMAR, ATUL SHARMA and KARTIK TOMAR	532

***In vitro* evaluation of endophytes and consortium for their plant growth promoting activities on rice seeds**

DAS, J., DEVI, R.K.T. and BARUAH, J.J.¹

College of Post Graduate Studies in Agricultural Sciences, Umiam, Meghalaya, ¹Assam Agricultural University, Jorhat

ABSTRACT: The present study entitled was conducted with an aim to find out the efficacy of endophytes and their Microbial Consortium (MC) on per cent germination of rice seeds and effect on vigour index of rice seedlings. The parameters for vigour index were recorded on 7th, 14th and 21st days after germination. Rice seeds of CAU-R1 variety was used for determining the plant growth promoting (PGP) activity of the endophytes alone and in consortium under *In vitro*. It was found that Microbial Consortium (MC) of endophytes showed more effectiveness than the individual endophytes on Per cent seed germination (98.33%) and vigour index after 7(778), 14(2134.50) and 21(2541.42) days of seed germination.

Key words: Consortium, endophytes, PGP activity

For a majority of the people of Asian and African countries, rice (*Oryza sativa* L.) is an important staple food. In India, more than 70% of people are directly or indirectly dependent on rice cultivation for their livelihood. Disease and pest infestations are one of the major constraints for increasing rice production. Diseases of rice are mainly caused by bacteria, fungi, virus, nematodes and as well as by phytoplasma. The seed borne pathogens may be both internally and externally associated within the rice grains (Kalyanasundaram, 1988). Reduction in seedling vigour and seedling mortality is also seen (Das and Narrain, 1988). In addition to these, toxins produced by different types of micro-organisms further deteriorates the quality of rice grains (Udagawa *et al.*, 1979). Endophytes are found everywhere in plant ranging from leaves, seeds, roots and even in the rhizospheric soil. In addition to providing resistance against various diseases to plants, it also helps in better growth of the plant (Lee *et al.*, 2004). Raupach and Kloepper (1998) reported that, combined application of antagonistic strains viz., *Bacillus pumilus*, *B. subtilis* and *Curtobacterium flaccumfaciens* enhanced growth promotion when used as seed treatment, as compared to the strains tested singly. Microbial consortium consisting of superior and efficient strains for growth promotion and biological control may prove to be a superior technique compared to traditional seed

treatment by chemicals.

MATERIALS AND METHODS

Isolation of bacterial endophytes

The present study was carried out in the Department of Plant Pathology, School of Crop Protection, College of Post Graduate Studies in Agricultural Sciences, (Central Agricultural University), Imphal, Umiam, Meghalaya in the year 2019-20. Isolation was done by following the method of Zinniel *et al.* (2002). Five *Bacillus* spp. were isolated from healthy rice leaves. Identification of the isolates was done by referring the guidelines described in the Bergey's Manual of Determinative Bacteriology (Holt *et al.*, 1994).

Functional attributes of screened bacterial endophytes

Functional attributes were studied for ammonia production (Thomas 1912, cellulose degradation (Gupta *et al.*, 2012), HCN production (Lorck, 1948), IAA production (Ehmann, 1977) and phosphate solubilization (Pikovskaya, 1948).

Development of Microbial Consortium (MC) Compatibility test among the isolates

The 5 isolates were tested for their compatibility among each other following the method of Fukui *et*

al., 1994.

Preparation of microbial formulation and consortium

Preparation of the consortia was done following the method described by Nandakumar *et al.*, 2001.

In vitro evaluation of endophytes alone and in consortium for their PGP activities

For the seed treatment by endophytes alone and consortium *In vitro*, rice seeds of CAU-R1 variety was used. The observations for per cent seed germination were recorded at 7 days after incubation.

$$\text{Germination (\%)} = \frac{\text{No. of seeds germinated}}{\text{No. of seeds kept for test}} \times 100$$

The observations for root length, shoot length and corresponding vigour index were calculated at 7, 14 and 21 days after germination by taking the method of Haque *et al.* (2007).

$$\text{Vigour Index (Vi)} = (\text{RL} + \text{SL}) \times \text{GP}$$

Where, RL = Root length (cm); SL = Shoot length (cm); GP = Germination per cent

RESULTS AND DISCUSSION

Functional attributes of bacterial endophytes

Ammonia production test

Four isolates of *Bacillus* spp. produced ammonia which was indicated by deep yellow to brownish colour of the broth culture tube (Fig 1).

Cellulose degradation test

Out of 5 isolates, 4 *Bacillus* spp. isolates showed positive reaction to cellulose degradation test which was indicated by formation of clear zone around the colonies (Fig 1).

HCN production test

All the isolates of *Bacillus* spp. showed negative reaction to HCN production test (Fig 1).

IAA production test

Out of 5 isolates of *Bacillus* spp., only two isolates viz., BC 3 and BC 8 showed positive reaction to IAA production test which was indicated by the appearance of pink colour of the broth culture (Fig 1).

Phosphate solubilization test

All the isolates of *Bacillus* spp. showed positive reaction to phosphate solubilization test which was indicated by the formation of clean zones around the spot inoculated colonies in Pikovskaya media (Fig 1).

Table 1: Cultural and morphological characters of 5 isolates of *Bacillus* spp.

Isolates/ Characters	BC 3	BC 6	BC 8	BC 10	BC 15
Cell shape	Rod	Rod	Rod	Rod	Rod
Colony colour	DW	DW	PW	C	C
Colony elevation	H	H	R	R	R
Colony margin	U	U	S	S	S
Colony shape	F	F	R	R	R
Gram reaction	-	-	-	-	-
KOH Test	-	-	-	-	-
Odour	+	+	+	+	+

C- Creamish; DW- Dull White; F- Flat; H- Hilly; PW- Pure White; R- Raised; S- Smooth; U- Undulated; (+): Positive result; (-): Negative result

Table 2: Functional attributes of 5 isolates of *Bacillus* spp.

Isolates/ Tests	BC 3	BC 6	BC 8	BC 10	BC 15
Ammonia production test	+	-	+	+	+
Cellulose degradation test	+	+	-	+	+
HCN production test	-	-	-	-	-
IAA production test	+	-	+	-	-
Phosphate solubilization test	+	+	+	+	+

(+) : Positive test; (-) : Negative test

Development of Microbial Consortium (MC)

Compatibility test among the efficient endophytes

The 5 isolates of *Bacillus* (BC 3, BC 6, BC 8, BC 10, BC 15) when streaked horizontally and vertically with each other in a nutrient agar plate, showed no zone of inhibition at the point of contact between each other after 72 h of incubation. Hence it can be said that the 5 isolates of *Bacillus* were compatible with each other and a Microbial Consortium (MC) was prepared (Fig 2).

In vitro evaluation of endophytes alone and in consortium for their PGP activities

Rice seeds treated with the 5 isolates of *Bacillus* (BC 3, BC 6, BC 8, BC 10, BC 15) and MC showed good germination Per centage (Fig 3) of 98.33% over

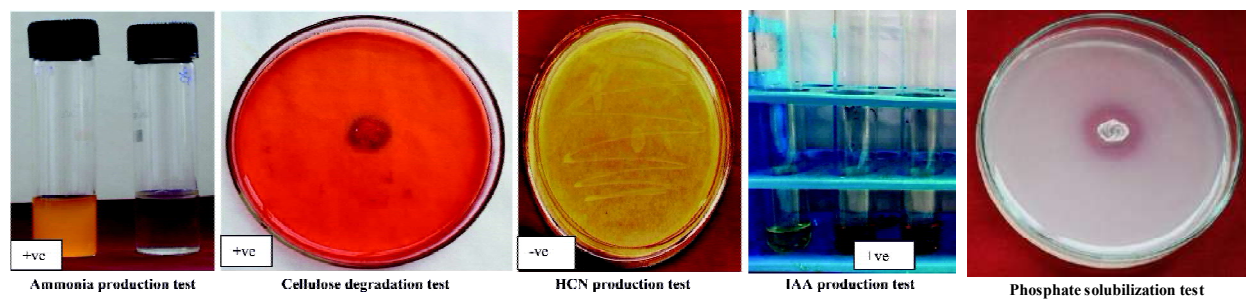


Fig 1: Functional attributes of 5 isolates of *Bacillus*

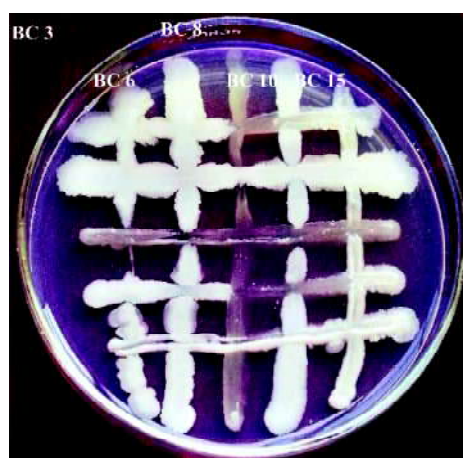


Fig 2: Compatibility test

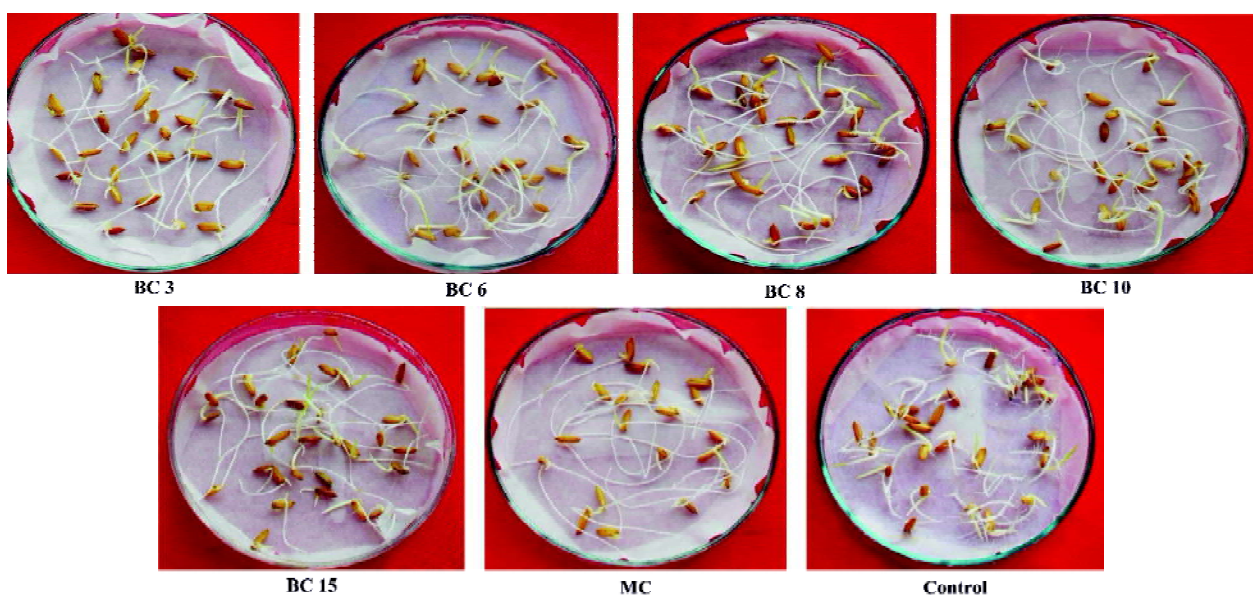


Fig 3: Efficacy of endophytes and consortium on rice seed germination



Fig 4a: Efficacy of endophytes and consortium on seedling vigour of rice seeds at 7 days after germination [a) BC 3
b) BC 6 c) BC 8 d) BC 10 e) BC 15 f) MC g) Control]

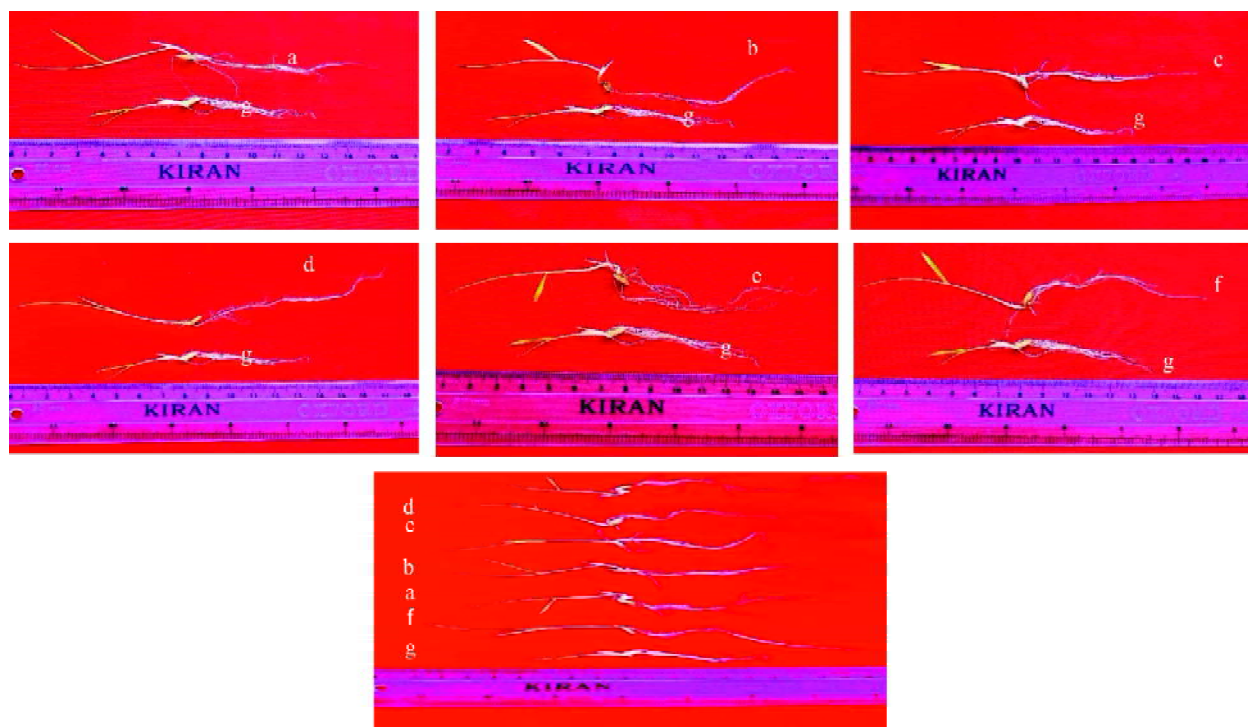


Fig 4b: Efficacy of endophytes and consortium on seedling vigour of rice seeds at 7 days after germination [a) BC 3
b) BC 6 c) BC 8 d) BC 10 e) BC 15 f) MC g) Control]

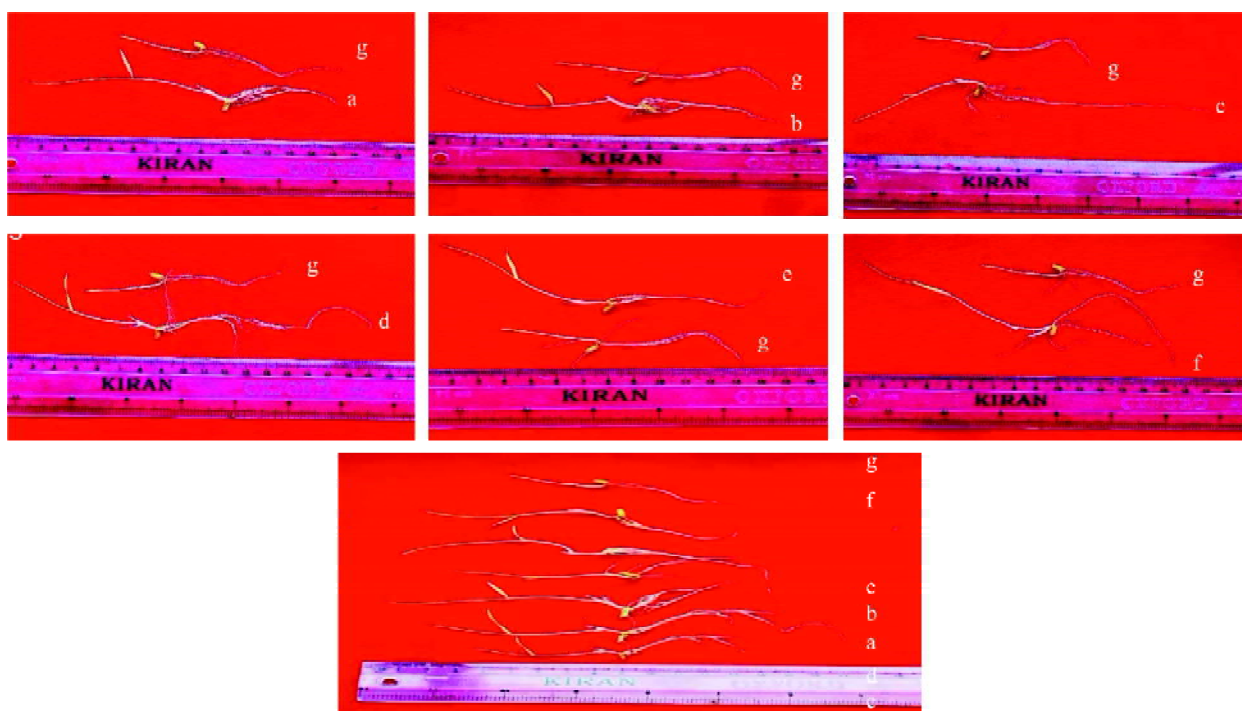


Plate 4 c: Efficacy of endophytes and consortium on seedling vigour of rice seeds at 7 days after germination [a) BC 3 b) BC 6 c) BC 8 d) BC 10 e) BC 15 f) MC g) Control]

control (81.66%). The individual isolates and MC showed maximum vigour index of rice seeds over control. MC exhibited maximum vigour index for 3 weeks after sowing (Table 3 and Fig 4).

CONCLUSION

The 5 endophytes were found to be compatible and a Microbial Consortium (MC) was formulated. Seed treatment of CAU-R1 with MC and individual 5 endophytes were found superior in maximum Percentage of seed germination and vigour index over control. So, further study can be carried out on field condition by testing the Microbial Consortium (MC) and mass production of the formulation can be taken up with efficient carrier system.

REFERENCES

- Das, A.N. and Narrain, A. (1988). Detection of grain discoloring fungal organisms of rice and production of disease free seeds. *J. Mycol. Pl. Pathol.*, 18: 24-30.
- Ehmann, A. (1977). The Van Urk- Salkowski reagent- a sensitive and specific chromogenic reagent for silica gel thin-layer chromatographic detection and identification of indole derivatives. *J. Chromatogr.*, 132(2): 267-276.
- Fukui, R., Schroth, M.N., Handson, M., and Hancock, J.G. (1994). Interaction between strains of *Pseudomonads* in sugar beet spermospheres and the relationship to pericarp colonization by *Pythium ultimum* in soil. *Phytopathol.*, 84: 1330-1332.
- Gupta, P., Samant, K., and Sahu, A. (2012). Isolation of cellulose-degrading bacteria and determination of their cellulolytic potential. *Int. J. Microbiol.*, 4: 1-5.
- Haque, A.H.M.M., Akon, M.A.H., Islam, M.A., Khalequzzaman, K.M., and Ali, M.A. (2007). Study of seed health, germination and seedling vigour of farmers produced rice seeds. *Int. J. Sustain. Crop Prod.*, 2(5): 34-39.
- Holt, J.G., Krieg, N.R., Sneath, P.H.A., Staley, J.T.,

Table 3: *In vitro* evaluation of PGP activities of the 5 isolates of *Bacillus* and Microbial Consortium (MC)

S. No.	Isolates	Germination (%)	Shoot length (cm)			Root length (cm)			Vigour Index		
			7	14	21	7	14	21	7	14	21
			(Days after germination)			(Days after germination)			(Days after germination)		
1	BC 3	91.66±1.66	1.31±0.08	8.27±0.14	9.79±0.12	5.84±0.08	8.60±0.16	9.82±0.18	655.93±9.90	1546.80±27.30	1798.16±42.32
2	BC 6	93.33±1.66	1.56±0.08	7.78±0.19	8.93±0.12	5.91±0.09	8.16±0.15	9.84±0.26	697.50±20.89	1487.26±13.59	1752.85±63.01
3	BC 8	91.66±1.66	1.18±0.08	8.18±0.24	9.95±0.12	6.02±0.03	8.54±0.30	9.26±0.14	661.26±22.59	1532.33±30.33	1853.70±44.95
4	BC 10	95.00±0.00	2.01±0.14	8.32±0.05	10.26±0.18	5.56±0.12	9.11±0.20	11.18±0.10	719.46±25.23	1656.80±21.90	2037.11±26.61
5	BC 15	93.33±1.66	1.40±0.17	8.00±0.07	9.66±0.29	6.22±0.07	9.18±0.16	11.05±0.13	711.90±15.33	1633.05±10.42	1932.96±30.15
6	MC	98.33±1.66	2.38±0.13	10.77±0.12	13.00±0.18	7.39±0.32	10.99±0.08	12.82±0.13	978.00±45.82	2134.50±48.85	2541.41±69.41
7	Control	81.66±1.66	0.70±0.10	5.97±0.32	6.32±0.12	4.33±0.03	7.92±0.17	8.64±0.17	411.43±12.90	1136.60±60.71	1222.22±49.21
CD (0.05)		4.72	0.34	0.58	0.78	0.43	0.58	0.61	74.74	106.79	171.86
Sem (±)		1.90	0.11	0.19	0.26	0.12	0.19	0.23	12.81	34.81	58.51

Data in the table are mean values of 3 replicates

- and Williams, S.T. (1994). Bergey's manual of determinative bacteriology, 9th edn. Williams & Wilkins, Baltimore, 787p.
- Kalyanasundaram, I.G.J. (1988). Storage fungi in rice in Karnataka, India. *Microb. Biotechnol.*, 14(2): 67-76.
- Lee, S., Encarnacion, M.F., Zentella, M.C., Flores, L.G., Escamilla, J.E., and Kennedy, C. (2004). Indole-3-acetic acid biosynthesis is deficient in *Gluconacetobacter diazotrophicus* strains with mutations in cytochrome c biosynthesis genes. *J. Bacteriol.*, 186: 5384-5391.
- Lorck, H. (1948). Production of hydrocyanic acid by bacteria. *Pl. Physiol.*, 1: 142-146.
- Nandakumar, R., Babu, S., Viswanathan, R., Raguchander, T., and Samiyappan, R. (2001). Induction of systemic resistance in rice against sheath blight disease by *Pseudomonas fluorescens*. *Soil Biol. Biochem.*, 33(4-5): 603-612.
- Pikovskaya, R.I. (1948). Mobilization of phosphorous in soil in connection with vital activity of some microbial species. *Mikrobiologiya*, 17: 362-370.
- Raupach, G.S. and Kloepper, J.W. (1998). Mixtures of plant growth promoting rhizobacteria enhance biological control of multiple cucumber pathogens. *Phytopathol.*, 88: 1158-1164.
- Thomas, P. (1912). Surune reaction coloree del'ammoniaque. *Bull. Soc. Chimique. Ser.*, 4(11): 796-799.
- Udagawa, S., Muroi, T., Kurata, H., Sekita, S., Yoshihira, K., Natori, S., and Umeda, M. (1979). The production of chaetoglobosins, sterigmatocystin, O-methylsterigmatocystin and chaetocin by *Chaetomium* spp. and related fungi. *Can. J. Microbiol.*, 25(2): 170-177.
- Zinniel, D.K., Lamrecht, P., Harris, N.B., Feng, Z., Kuczmarski, D., Higley, P., Ishimaru, C.A., Arunakumari, A., Barletta, R.G., and Vidaver, A.K. (2002). Isolation and characterization of endophytic colonizing bacteria from agronomic crops and prairie plants. *Appl. Environ. Microbiol.*, 68(5): 2198-2208.

Received: December 9, 2021
Accepted: December 12, 2021