



Metabolism of indole acetic acid within the root nodules and changes of edaphic factors in the rhizospheric area of *Vigna radiata*

Sisir Ghosh

Department of Botany, Sreegopal Banerjee College, Bagati, Mogra, Hooghly-712148, West Bengal, India
e-mail: sisirghosh1981@gmail.com

Manuscript details:

Received: 06.07.2026
Accepted: 08.09.2026
Published: 30.09.2026

Cite this article as:

Sisir Ghosh (2026) Metabolism of indole acetic acid within the root nodules and changes of edaphic factors in the rhizospheric area of *Vigna radiata*. *Int. J. of Life Sciences*, 14 (3): 263-269.

Available online on <http://www.ijlsci.in>
ISSN: 2320-964X (Online)
ISSN: 2320-7817 (Print)

ABSTRACT

The mature root nodules of *Vigna radiata* (L.) R. Wilczek (Mung bean), a pulse legume, contained significant amount of indole acetic acid (IAA) and total phenol, which were greater than non-nodulated roots. A remarkable amount of tryptophan pool both in the mature root nodules and the non-nodulated roots were found as the precursor molecule of IAA. Presence of IAA oxidase and peroxidase, the IAA metabolising enzymes, in the mature root nodules and non-nodulated roots indicated the metabolism of IAA in the nodules and roots. Metabolism of phenol by enzymes in both root nodules and roots controlled the IAA production in those tissues. Decomposition of the mature root nodules were increased the percentage of average organic carbon and total nitrogen over control as the root nodules were mixed up with the soil after decomposition. The important physiological implications of the IAA production and the changes of edaphic factors of the rhizospheric area in the light of legume-Rhizobium symbiosis were discussed.

Keywords: *Vigna radiata*, root nodule, indole acetic acid, edaphic factors, symbiosis

INTRODUCTION

Leguminous plants (under the family Fabaceae), which belong to the third largest (after Orchidaceae and Asteraceae) family of angiosperms (Mabberley, 1997), include approximately 750 genera (Christenhusz and Byng, 2016) and about 20000 species worldwide (Christenhusz and Byng, 2016), which constitute 7% of overall flowering angiosperms (Judd *et al.* 2002). Rhizobia include about 98 species and 13 genera (Weir, 2016). The rhizospheric area of the leguminous plants contain plant growth promoting rhizobacteria (PGPR), that are able to colonize the rhizospheric area including the roots (Azhrufuzzaman *et al.* 2009) and promote growth by direct or indirect mechanisms (Widowati *et al.* 2019). Again rhizobacterial production of indole acetic acid (IAA) also performed as effective plant growth promoting activity along with other symbiotic interactions (Kiruthika and Arunkumar, 2021). Apart from the symbiotic IAA production by rhizobacteria, promotion of growth by IAA produced by blue-green algae *Desertifilum* sp. in green gram was also reported by Palraj *et al.* (2025).



Open Access This article is distributed under the terms of the **Creative Commons**

Attribution 4.0 International License (CC BY 4.0), which permits any use, provided proper credit is given to the author and source, a link to the license is provided, and changes are indicated. Third-party material is included under the same license unless otherwise credited. If your intended use is not permitted by the license or statutory exceptions, you must obtain permission from the copyright holder. Full license details: <http://creativecommons.org/licenses/by/4.0/>

As non-rhizobial endophytic bacterial genera there were also three species of *Bacillus* reported for IAA production and its *in vitro* application for the growth in *Vigna radiata* (Bhutani *et al.* 2018). Rhizobia, which include more than 98 species within 14 genera (Berrada and Fikri-Benbrahim, 2014), are bacteria capable of fixing atmospheric nitrogen and forming root nodules in plants of the family Fabaceae. Only 20% of the leguminous plants have been examined for nodulation (Hopkins, 1999) and only 0.5% of the legumes have been studied in relation to the nodule bacteria (Jordan, 1984). Different phytohormones in variable amount detected by different researchers in the root nodules act important roles in genesis and development (Nutman, 1977; Verma *et al.* 1992) and formation (Kefford *et al.* 1960) of root nodules during the course of symbiosis. IAA also performed an important role as mitigator after ameliorated lead (Pb) stress by declining the reduction rate of photosynthesis and stomatal conductance (Saleem *et al.* 2021). Development of a successful symbiosis is the results of a complex series of interactions within the host tissues between the host and the symbiont (Pellock *et al.* 2000). The successful symbiotic establishment with leguminous host plants depends on the production of Nod factor signals and exposure of the correct surface and/or extracellular polysaccharide (EPS), which involved in root hair infection and nodule formation (Phillip-Hollingsworth *et al.* 1989). Leguminous plants possessed large numbers of microbes in its rhizospheric area including *Rhizobium* sp. which help in the development of root nodules. Several factors like soil pH, soil moisture, C and N ratio, organic matter content, numbers of nodule etc. were found to influence the rhizosphere of the legume. *Rhizobium* sp. could increase the percentage of organic carbon into soil in several ways including the decomposition of mature root nodules, besides increasing the soil nitrogen content.

Vigna radiata (L.) R. Wilczek (Mung bean), also known as green gram, is one of the important legumes cultivated for its edible seeds and sprouts across Asia. The plant is also widely cultivated in tropical and subtropical areas of the World for its edible seeds and economic benefit. The well-known economic plant is often used in mixed cropping system and thereby crop rotation to provide nitrogen, improve soil fertility and control pest and diseases (Widowati *et al.* 2019). Mung bean has immense nutritional value due to its high protein contents and is consumed in the form of whole

seeds, split peeled seeds and sprouts (Bhutani *et al.* 2018). The present work has shed some light on changes of the edaphic factors of soil surrounding root system of mung bean. The changes take place in the content of nitrogen, carbon, phosphorus, soil moisture etc. during the growth and nodulation of the plant in the soil and IAA metabolism in root and nodule.

MATERIAL AND METHODS

The pulse legume *Vigna radiata* (L.) R. Wilczek (Mung bean) was selected for study. The certified seeds were collected from a reputed seed-selling centre of Burdwan, WB. The plants were grown in experimental plots, different places in experimental plots were selected for collection of soil samples before plantation and after the decomposition of nodules. Soil samples were dried in hot air oven for 3-4 h at 75±2°C. Dried soil samples were stored in sterile plastic bags till analysed.

Estimation of soil nitrogen, carbon and phosphorus:

Total nitrogen and carbon was estimated from soil sample by following methods of Vogel (1961) and Black (1965) respectively. Available phosphorus was estimated by following method of Jackson (1968).

Determination of soil moisture and pH:

Soil moisture and soil pH were determined by the methods of Kapur and Govil (2000) and Jackson (1968) respectively.

Extraction of IAA, tryptophan and total phenol from root nodules and roots and their estimation:

Mature, fresh root nodules and young roots are selected for the experiment. IAA was extracted from fresh tissues of the plant. About 5 g each of roots and root nodules were taken for extraction of IAA and purified by repeated thin layer chromatography (TLC) following Sinha and Basu (1981) with slightly modification by Ghosh and Basu (2006) and was estimated colorimetrically following Gordon and Weber (1951) using a standard curve prepared from authentic IAA sample. Tryptophan was extracted from both root and root nodules according to Nitsch (1955) and estimated colorimetrically following Hassan (1975). The total phenol content was extracted and estimated from both the tissues after Bray and Thorpe (1954).

Extraction and estimation of IAA-metabolizing and phenol-metabolizing enzyme:

IAA-oxidase from both root and root nodule was extracted and estimated following Sinha and Basu (1981). Oxidation of IAA by the enzyme peroxidase within both the tissues was estimated following Kokkinakis and Brooks (1979) with modification by Datta and Basu (1998). Peroxidase and polyphenol-oxidase were extracted from root and root nodule and estimated according to Kar and Mishra (1976). The total protein content in the enzyme was estimated following Lowry *et al.* (1951).

Isolation and cultivation of the symbiont and estimation of IAA production

Isolation and cultivation of the symbiont were done following the methods mentioned by Ghosh and Basu (2006). L-tryptophan was used to check the ability of IAA production by the symbiont as per the method standardized by Ghosh *et al.* (2008). The active growth of the symbiont was measured at 540 nm turbidimetrically and the IAA produced by the

symbiont was measured from the extracted supernatant following Gordon and Weber (1951). Statistical analyses were carried out following Panse and Sukhatme (1985) after taking three replicates from each experiment.

RESULTS AND DISCUSSION

The plant *Vigna radiata* (L.) R. Wilczek produced plenty of root nodules after 60 days of growth. Out of total number of nodules (both mature and immature) near about $\frac{1}{4}$ of the nodules were immature (Table 1) and the mature nodules were small, spherical to globose and pinkish in colour.

Higher amount of IAA was detected and estimated within the mature root nodules of the plant in comparison with young roots (Table 2). Within both the mature root nodules and the young roots a tryptophan pool was found. Mature root nodules contained higher level of total phenol than of young roots (Table 2).

Table 1: Total number of Root nodules (mature and immature) found in the plant *Vigna radiata* (L.) R. Wilczek.

Plant ¹	Mature root nodules	Immature root nodules	Total
Plant-1	32	10	42
Plant-2	33	09	42
Plant-3	27	09	36
Plant-4	38	11	49
Plant-5	37	12	49
Plant-6	35	13	48
Plant-7	28	11	39
Plant-8	36	12	48
Plant-9	30	10	40
Plant-10	34	13	47
Total	330	110	440
Average	33	11	44

¹Age of all plants- 60 days

Size of plants- 14-18 inches

Time of year data taken-September

Whether manure given or not- not given

Flowering came or not- before flowering

Table 2: Maximum level of Indole acetic acid (IAA), tryptophan and total phenol found in nodules and roots of *Vigna radiata* (L.) R. Wilczek.

Plant Parts	IAA	Tryptophan	Phenols
	(µg/g fresh tissue)		
Nodule	22.32	1762	1538
Root	3.12	352	962
Critical Difference at P = 0.05	0.07	3.05	8.47

(IAA, tryptophan and total phenol were estimated colorimetrically)

The IAA might transport from root nodules to other parts of the plant. It was also expected more free phenols in root nodules of the plants because the nodules possess higher IAA and lower IAA-catabolising enzyme activity than roots. Higher quantities of total phenol in the root nodules than young roots would result from the lower polyphenol-oxidase and peroxidase activity in the root nodules (Stafford, 1974) than the young roots.

Presence of IAA-metabolising enzymes in both root nodules and roots indicated the metabolism of IAA in these tissues. The root always contained higher amount of IAA-oxidase and peroxidase, the IAA-metabolising enzymes, than the root nodules (Table 3).

The presence of higher amount of IAA-metabolising enzymes in roots resulted the lesser amount of IAA in that tissues. The amount of IAA was controlled as per the necessity by the tissues accordingly and plays an important role for the persistence of functional root nodules (Badenoch-Jones *et al.* 1983). Improved crop yield like quality of cotyledons, seed weight and seed numbers per pod was recorded after IAA application on *Vigna radiata* (Pandey *et al.* 2025).

The activity of the peroxidase and polyphenol-oxidase, two phenol-metabolising enzymes, were lesser (Table 4) due to the presence of higher levels of total phenols in the root nodules than the roots (Table 2). As the nodules possess higher IAA and lower IAA-catabolising enzyme activity than roots, it was also expected more free phenols in root nodules of the plants.

Higher amount of tryptophan, acts as precursor of IAA, present in the root nodules might be helped in higher

IAA production in those tissues than that of roots. The IAA-metabolising enzymes, IAA-oxidase and peroxidase might actively control the IAA production in tissues. The cause of difference of the quantity of total phenol levels in different plant parts would also be due to the variation in the metabolism and synthesis of total phenols in different plant tissues by phenylalanine-ammonia lyase and tyrosine-ammonia lyase (Stafford, 1974; Vance, 1978).

The percentage of average organic carbon and total nitrogen were increased as the root nodules of this plant were mixed up with the soil after decomposition (Table 5). The percentage of available phosphorus was also increased after decomposition (Table 5). The percentage of soil moisture was decreased gradually with the gradual decrease of soil depth from surface level (Table 6).

The symbiont isolated from the mature nodule was cultivated in yeast extract mannitol medium following Ghosh and Basu (2006).

The symbiont showed the results (data not shown) in various physiological and biochemical characteristics following Ghosh *et al.* (2008) which were similar with a fast-growing *Rhizobium* sp. When the symbiont was grown in the L-tryptophan supplemented medium, it was found that the symbiont produced maximum IAA at a rate of specific productivity (production versus growth) 161.11 along its growth (Fig. 1) when the culture was inoculated for 18 h at $30 \pm 2^\circ\text{C}$. The production of IAA in culture by the symbiont supported the result of estimation of higher amount of IAA from the mature root nodule than that of the non-nodulated root

Table 3. Catabolism of IAA by IAA-oxidase and peroxidase in nodules and roots of *Vigna radiata* (L.) R. Wilczek.

Plant parts	IAA-oxidase (mg IAA oxidised/mg protein/h)	Peroxidase (mg IAA oxidised/mg protein/h)
Nodule	11.30	7.75
Root	38.25	10.20
Critical difference at P=0.05	0.22	0.13

Table 4. Levels of total peroxidase and polyphenol oxidase in nodules and roots of *Vigna radiata* (L.) R. Wilczek.

Plant parts	Peroxidase (mg purpurogallin formed/mg protein/min)	Polyphenol-oxidase (mg purpurogallin formed/mg protein/min)
Nodule	157.24	136.36
Root	188.48	152.12
Critical difference at P=0.05	2.05	1.10

Table 5: Changes of carbon, nitrogen and phosphorus before and after plantation of *Vigna radiata* (L.) R. Wilczek.

Place of collection of soil sample	% of organic carbon (C)	% of total nitrogen (N)	C : N	% of available phosphorus
Soil before plantation	0.38	0.11	3.45	0.0085
Soil having nodulated plant (after decomposition)	1.65	0.67	2.46	0.0115

Percentage of organic carbon, total nitrogen, available phosphorus before and after plantation of *Vigna radiata* (L.) R. Wilczek. Data presented here were the mean of three experimental sets.

Table 6: Changes of soil moisture content

Soil depth (cm)	Fresh weight of soil sample (g)	Dry weight of soil sample (g)	Weight of water (g)	Soil moisture (%)
0-5	100	75.0	25.0	33.33
5-10	100	79.3	20.7	26.10
10-15	100	82.1	17.9	21.80

Percentage of soil moisture at different depths of soil in the field during cultivation of *Vigna radiata* (L.) R. Wilczek. Data presented here were the mean of three sets.

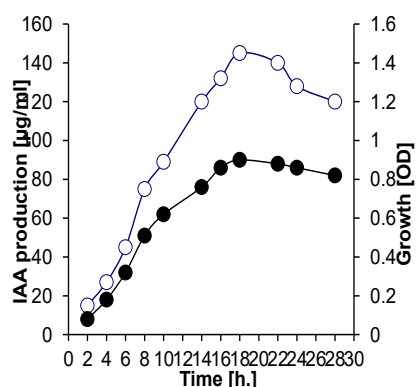


Fig. 1: Growth [●] of the symbiont of *Vigna radiata* and its IAA production [○] in culture. The symbiont was grown in culture medium containing L-tryptophan for 28h at $30 \pm 2^\circ\text{C}$.

The organisms present in the nodule have the capacity to increase the organic matter besides nitrogen fixation. The percentage of available phosphorus changed very little after decomposition of the root nodules into the soil. It might be due to the use of the soil phosphorus by the soil organisms. It has been reported that C:N ratio was affected by soil properties such as moisture content, texture, pH (Anderson and Domsch, 1980; Campbell *et al.* 1991) and the C:N ratio is often used to describe the structure and the state of

the microbial community (Kaushik *et al.* 2006). The gradual decrease of soil moisture with depth was due to the root system of the plant as the rootlets and roots were spread in the soil just below the surface level and hold the soil water. Mature plants contained numerous root nodules and caused by the native rhizobia already present into the soil.

The study indicates that the root nodule forming rhizobacteria may help to metabolize the growth promoting phytohormone i. e. IAA by IAA-metabolizing enzymes within the plant tissues. Formation of root nodules and production of IAA have much beneficial effects as the nodule tissues are the good sources of this phytohormones. As a mark of sustainable development and promotion of edaphic factors, co-cultivation of *Vigna radiata* and rice was also effective due to higher production of IAA by the root nodule and its supply to the soil as biofertilizer was reported by Palraj *et al.* (2025). Metabolism of this phytohormone within the plant tissues might have another importance as the edaphic factors of the rhizospheric area were changes which results the increase of soil nutrients for the plant growth. Combined effect of IAA as growth regulator along with Boron as micronutrient jointly played a vital role for the development of healthy maize crop was also reported (Hussain *et al.* 2025). Earlier it was also established that plant growth promoting rhizobacteria (PGPR) of *Vigna mungo* were also applied to reduce the use of chemical fertilizers and pesticides in agricultural land; also to remove the pollution from

environment; to control the health hazard and to increase of distribution of biotic groups during growth and development (Kiruthika and Arunkumar, 2021). So hopefully the study will help to increase the knowledge of crop rotation and cultivation of crops without or lesser use of chemical fertilizers in agriculture.

Conflict of interest

The authors declare no competing interests.

Data Availability Statement: Not applicable.

Correspondence and requests for materials should be addressed to **Sisir Ghosh**

Reprints and permissions information is available at <https://www.ijlsci.in/reprints>

REFERENCES

- Anderson JPE and Domsch KH (1980) Quantities of plant nutrients in the microbial biomass of selected soils. *Soil Sci*, 130: 211-216.
- Azhrafuzzaman M, Farid AH, Ismail MR, Hoque MA, Islam MZ and Shadidullah SM (2009) Efficiency of plant growth promoting rhizobacteria (PGPR) for the enhancement of rice growth. *Afr J Biotechnol*, 8:1247-52.
- Badenoch-Jones J, Rolfe BG, Letham DS (1983) Phytohormones, *Rhizobium* mutants and nodulation in legumes. III. Auxin metabolism in effective and ineffective pea root nodules. *Plant Physiol*, 73: 347-352.
- Berrada H and Fikri-Benbrahim K (2014) Taxonomy of the Rhizobia: Current Perspectives. *British Microbio Res Journal*, 4(6): 616-639.
- Bhutani N, Maheshwari R, Negi M and Suneja P (2018) Optimization of IAA production by endophytic *Bacillus* spp. from *Vigna radiata* for their potential use as plant growth promoters. *Israel J of Plant Sci*, 65: 1-2.
- Black CA (1965) Methods of Soil Analysis. Vol. 2. American Society of Agronomy.
- Bray HG and Thorpe MV (1954) Analysis of phenolic compounds of interest in metabolism. Vol. I. In: Glick, D. (Eds), Methods of Biochemical Analysis. *Intersci Publ*, New York, 17-52.
- Campbell CA, Biederbeck VO, Zentner RP, and Lafond GP (1991) Effect of Crop rotations and cultural practices on soil organic matter, microbial biomass and respiration in a thin black Chernozem. *Can J Soil Sci*, 71: 363-376.
- Christenhusz MJM and Byng JW (2016) [The number of known plants species in the world and its annual increase](#). *Phytotaxa*, 261 (3): 201-217.
- Datta C and Basu PS (1998) Production of Indole Acetic Acid in Root Nodules and Culture by a *Rhizobium* species from Root Nodules of the Fodder Legume *Melilotus alba* DESR. *Acta Biotechnol*, 18(1): 53-62.
- Ghosh S and Basu PS (2006) Production and metabolism of indole acetic acid in roots and root nodules of *Phaseolus mungo*. *Microbiol Res*, 161: 362-366.
- Ghosh S, Sengupta C, Maiti TK and Basu PS (2008) Production of 3-Indolylacetic Acid in Root Nodules and Culture by a *Rhizobium* Species Isolated from Root Nodules of the Leguminous Pulse *Phaseolus mungo*. *Folia Microbiol*, 53(4): 351-355.
- Gordon SA and Weber RP (1951) Colorimetric estimation of indole-acetic acid. *Plant Physiol*, 26: 192-195.
- Hassan SSM (1975) Spectrophotometric method for simultaneous determination of tryptophan and tyrosine. *Anal Chem*, 47: 1429-1432.
- Hopkins W G (1999) Introduction to Plant Physiology, 2nd edition. John Wiley and Sons Inc., New York.
- Hussain K, Ghaus H, Amin R, Nawaz K, Ahlawat Y, Elhindi KM, Malik A, Bashir S, Iqbal I and Arshad N (2025) Straight Vs. blended application of IAA (Indole Acetic Acid) and Boron (B) for the improvement of crop productivity in maize (*Zea mays* L.), *BMC Plant Biology*, 25: 1648.
- Jackson ML (1968) Soil chemical Analysis. Prentice-Hall, London.
- Jordan DC (1984) Rhizobiaceae. In: Bergey's Manual of Systematic Bacteriology, vol. 1. In: Krieg, N. R., Holt, J. G., (Eds.), Williams and Wilkins Co., Baltimore, U.S.A., 235-240.
- Judd WS et al. (2002) Plant Systematics: a phylogenetic approach, Sinauer Associate. Pp. 287-92, ISBN: 978-0-87893-403-4.
- Kapur P and Govil SR (2000) Experimental Plant Ecology, CBS Publishers and Distributors (New Delhi).
- Kar M and Mishra D (1976) Catalase, peroxidase, and polyphenol oxidase activities during rice leaf senescence. *Plant Physiol*, 57: 315-319.
- Kaushik R, Sharma DK and Joshi HC (2006) Impact on short term changes in soil microbial biomass, carbon and nitrogen dynamics due to irrigation with distillery effluent in rice-wheat cropping system. *Ind J Microbiol*, 46(2): 139-145.
- Kefford NP, Brockwell J and Zwar JA (1960) The symbiotic synthesis of auxin by legumes and nodule bacteria and its role in nodule development. *Aust J Biol Sci*, 13: 456-467.
- Kiruthika S and Arunkumar M (2021) A comprehensive study on IAA production by *Bradyrhizobium japonicum* and *Bacillus subtilis* and its effect on *Vigna radiata* plant growth. *Indian Journal of Agricultural Research*, 55(5): 570-576.
- Kokkinakis DM, and Brooks JL (1979) Hydrogen peroxidase mediated oxidation of indole-3-acetic acid by tomato peroxidase and molecular oxygen. *Plant Physiol*, 64: 220-223.
- Lowry OH, Rosebrough NJ, Farr AL and Randall RJ (1951) Protein estimation with folin phenol reagent. *J Biol Chem*, 193: 265-275.

- Mabberley DJ (1997) The plant book, 2nd ed. Cambridge University Press, Cambridge, UK.
- Nitsch JP (1955) Free auxin and free tryptophan in strawberry. *Plant Physiol*, 30: 33-39.
- Nutman PS (1977) Study frame works for symbiotic nitrogen fixation. In: Newton W., Postgate J.R., Rodriguez Barrueco C. (Eds.), Recent Developments in Nitrogen Fixation. Academic Press, London, 443-447.
- Palraj P, Subraswami V, Zimik Z and Paranthaman S (2025) Indole 3-acetic acid production and growth-promoting effect of *Desertifilum* sp. PSL17 on *Vigna radiata*. *Frontiers in Industrial Microbiology*, 3:1594031.
- Pandey PO, Valvi GR and Mahajan JS (2025) Effect of Growth Regulator IAA on *Vigna radiata* L. (Green Gram). *International Journal of Multidisciplinary Research (IJFMR)*, Vol 7, Issue 3, 1-4.
- Panase VG and Sukhatme PV (1985) Statistical Methods for Agricultural Workers, 4th ed. Indian Council of Agricultural Research, New Delhi, 145-156.
- Pellock BJ, Cheng HP and Walker GC (2000) Alfalfa root nodule invasion efficiency is dependent on *Sinorhizobium meliloti* polysaccharides. *J Bacteriol*, 182: 310-313.
- Phillip-Hollingsworth S, Hollingsworth RI and Dazzo FB (1989) Host-range related structural features of the acidic extracellular polysaccharides of *Rhizobium trifolii* and *Rhizobium leguminosarum*. *J Biol Chem*, 264: 1461-1466.
- Saleem S, Yasin G, Haq IU, Altaf A, Hussain K and Nawaz K (2021) Indole Acetic Acid (IAA) Mediated Amelioration of Lead (Pb) Stress, Legume Research, Vol 44, Issue 10: 1152-1158
- Sinha BK and Basu PS (1981) Indole-3-acetic acid metabolism in root nodules of *Pongamia pinnata* (L.). *Pierre Biochem Physiol Pflanzen*, 176: 218-227.
- Stafford HA (1974) The metabolism of aromatic compounds. *Annu Rev Plant Physiol*, 2: 459-486.
- Vance CP (1978) Comparative aspects of root and nodule secondary metabolism. *Phytochem*, 17: 1889-1891.
- Verma DPS, Hu CA and Zhang M (1992) Root nodule development: origin, function and regulation of nodulin genes. *Physiol Plant*, 85: 253-265.
- Vogel AI (1961) A Text Book of Quantitative Inorganic Analysis. London, Longman.
- Weir BS (2016) The current taxonomy of rhizobia. New Zealand Rhizobia. website. <https://www.rhizobia.co.nz/taxonomy/rhizobia.html>, Jan, 2016.
- Widowati T, Nuriyanah, and Sukiman H (2019) Production of indole acetic acid by *Enterobacter cloacea* H3 isolated from Mungbean (*Vigna radiata*) and its potential supporting the growth of soybean seedling. *IOP Conf Ser: Earth Environ Sci*, 308: 012040.

Publisher's Note

IJLSCI remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.