choose one or more of these criteria in K-nutrition to obtain the best results.

Most of the farmers in the study area either relied on conventional knowledge or approached not very professionally skilled consultants (many a times fellow farmers). Owners of the high-output vineyards tend to use higher rates of K fertilizers, primarily to improve fruit quality. It appears that the economic conditions of farmers played small role in deciding the rate of K-fertilizer application. It was mostly the awareness that a farmer did not have about optimum ranges for soil, petiole and yield which could be achieved with proper fertilizer application. The K-optimization goals proposed in this study are easy to follow. Multiple parameter ranges as suggested in this study would also provide an opportunity to influence more growers to adopt these optima, since farmers do not seem to be much aware of diagnosis techniques, nor do they have access to expert consultancy. This study brings out clear and simple ranges for diagnostic parameters used for K fertilization in the country which are easier for farmers to follow and maximize returns from their vineyards.

1. Savci, S., *APCBEE Procedia*, 2012, **1**, 287–292.
2. Nangia, V., Gowda, P. H. and Mulla, D. J., *Agric. Water Manage.*, 2010, **97**(11), 1855–1860.
3. Ruan, L., Bhardwaj, A. K., Hamilton, S. K. and Robertson, G. P., *Environ. Res. Lett.*, 2016, **11**(6), 064007.
4. Pathak, R. K. and Ram, R. A., *Prog. Hortic.*, 2013, **45**(2), 238–254.
5. This, P., Lacombe, T. and Thomas, M. R., *Trends Genet.*, 2006, **22**(9), 511–519.
6. Shikhamany, S. D., In *Grape Production in the Asia-Pacific Region* (eds Papademetriou, M. K. and Dent, F. J.), FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 2001; http://www.fao.org/docrep/003/x6897e/x6897e06.htm (accessed on 27 July 2016).
7. Martinson, T. E., Mansfield, A. K., Luby, J. J., Gartner, W. C., Dharmadhikari, M. and Domoto, P., *Acta Hortic*., 2016, **1115**, 3–12; doi:10.17660/ActaHortic.2016.1115.2.
8. Gierth, M. and Maser, P., *Plant Transport. Channels*, 2015, **581**(12), 2348–2356.
9. Nasir, M., Khan, A. S., Ahmad Basra, S. M. and Malik A. U., *Sci. Hortic*., 2016, **210**, 227–235.
10. Ganeshamurthy, A. N., Satisha, G. C. and Patil, P., *Karnataka J. Agric. Sci*., 2011, **24**(1), 29–38.
11. Abd El-Razek, E., Treutter, D., Saleh, M. M. S., El-Shammaa, M., Amera, A. F. and Abdel-Hamid, A., *Agric. Biol. J. North Am.*, 2011, **2**(2), 330–340.
12. Arora, N. K., Gill, M. I. S. and Navjot, *HortFlora Res. Spectr.*, 2012, **1**(1), 17–23.
13. Wang, M., Zheng, Q., Shen, Q. and Guo, S., *Int. J. Mol. Sci.*, 2013, **14**, 7370–7390.
14. Usherwood, N. R., In *Potassium in Agriculture* (ed. Munson, R. S.), ASA-CSSA-SSSA, Madison, WI, USA, 1985, pp. 489–513.
15. Pollack, M. and Fisher, H. W., *Arch. Biochem. Biophys.*, 1976, **172**(1), 188–190.
16. Nagaraja, M. S., Bhardwaj, A. K., Reddy, G. V. P., Srinivasamurthy, C. A. and Sandeep Kumar, *Solid Earth*, 2016, **7**, 897–903.
17. Goudappanavar, B., Patil, D. R., Nanjappanavar, A., Tattimani, M., Naik, R. and Mahesh, S., *Fruit Sci.*, 2016, 5, 2277–8179.

ACKNOWLEDGEMENTS. We thank the Vice Chancellor, University of Horticultural Sciences, Bagalkot, who encouraged us to look for farmer-oriented results and field-applicable solutions.

Received 30 August 2016; revised accepted 8 November 2018

VINOD C. NARABOLI[1]
S. SRIKANTH[1]
AJAY K. BHARDWAJ[1,2,*]
SHANKAR METI[1]
ASHOK S. ALUR[1]
MAVINAKOPPA S. NAGARAJA[1]

[1]*Department of Soil Science, College of Horticulture, University of Horticultural Sciences, Bagalkot 587 102, India*
[2]*ICAR-Central Soil Salinity Research Institute, Karnal 132 001, India*
**For correspondence.*
e-mail: ak.bhardwaj@icar.gov.in

Brainea insignis (Hook.) J.Sm. – a conservation priority fern of North East India

A false tree fern, *Bowringia insignis* Hook., was described by Hooker[1] as a new genus to honour John Bowring and his son, J. O. Bowring, who first sent live plants of it from Hong Kong for introduction to the Royal Botanic Garden, Kew, London. Taxonomically *Bowringia* Hooker (1853) was an illegitimate later homonym of *Bowringia* Champ. ex Benth. (1852, Fabaceae) and a new name, *Brainea*, was therefore proposed for this fern-genus to honour J. C. Braine[2], who had also introduced it at Kew in 1850.

Brainea is a monotypic genus of false tree ferns represented by *Brainea insignis* (Hook.) J.Sm. (family Blechnaceae). The plant has a thick, upright or ascending, slow-growing trunk which may attain a height up to 1 m. The apex of the trunk bears a compact radiating basket of many fronds giving the appearance of a cycad; hence it is often called 'cycad fern' in the nursery trade. The individual plants are scattered in often large colonies on open or semi-shaded slopes. Like cycad, *Brainea* is also a perennial plant; it can survive for several years and thrive in warm and exposed places. The fronds are unipinnate with long, narrow, pointed, glossy green pinnae which are light green or glaucous white on the under surface. The naked sori are produced on the under surface of leaf segments in a line along the reticulate veins (Figure 1).

B. insignis is a native to Southeast Asia (India, Myanmar, Malay Peninsula, Philippines, Thailand, Taiwan, Vietnam, Indonesia, Sumatra and south China)[3,4]. North East India is its westernmost limit,

where it has a rather restricted and scattered distribution between 500 and 1400 m. It grows in specific habitats and its populations are apparently declining throughout the globe[5–7]. Earlier this species was not listed under any threat category of Indian plants[8,9], mainly because in the previous Red-data lists much attention was paid on higher plants and pteridophytes were treated superficially. However, in recent more careful assessments of RET Indian pteridophytes, it is listed under the Near Threatened (NT) category of IUCN[5,10,11]. In China and Taiwan, it is vulnerable and mentioned as a category II plant under the State Protection Act of Hong Kong[7].

During the present study it is found that *B. insignis* is one of the rare ferns of India. For the assessment of rare, endangered and threatened species herbarium data are also used as an important tool[12]. The limited number of herbarium sheets of *B. insignis* housed in different herbaria also reflects its sparse and scattered distribution in India. In 19th century, it was collected only from Khasi hills (Meghalaya)[13] by the British (housed in different herbaria, CAL, ASSAM, DD, K, BM, US, L, etc.). Later it was also collected from the Naga hills [Sarpung (?Soraphung), Naga Hills, 5000 ft., *A. Meebold* 7147, in 1907, CAL], in Tecropol Forest Division, Manipur (Lonkhai forest, 250 m, *B. Ghosh* 59487, 31-3-1985) and Murlen National Park, Mizoram (Champai, *S. Sharma* 129987, 4-3-2014) with a single gathering from each state. Most of the existing populations of *Brainea* are in Meghalaya near the Barapani Dam, with several plants. However, some other localities such as West of Mawlai overlooking Beadon Fall, have been completely destroyed by severe burning in the last 15 years (C. R. Fraser-Jenkins, pers. commun.). This fern has also been cultivated in Shillong town, for several decades and recently also introduced in Experimental Botanical Garden at Barapani and office campus of the Botanical Survey of India (BSI), Shillong. The recent collections at Assam are either from Barapani or Shillong.

Figure 1. *Brainea insignis* (Hook.) J. Sm. ***a***, Habit, ***b***, tall plant, ***c***, pinnules showing sori along the veins.

Presently, the species is in peril in India due to several anthropogenic factors. Habitat destruction and fragmentation is noted as the major threat to this species mainly due to Jhum cultivation[14] and for change in land use. Coal mining, township development, road-cutting, settlement near roads, converting forest land into agriculture land, tea gardens, pineapple cultivation, etc. are responsible for the decline of this species. Socio-economically it is also used by locals for extraction of fibre and making brushes; however, we have not recorded use of its starchy pith as food, fodder, or in making a local beverage after fermentation, unlike in true tree ferns.

B. insignis grows in open slopes of pine forests, and is prone to frequent fires in this habitat. The thick and massive trunk is somewhat fire-resistant and can endure seasonal forest fire, but juvenile plants, sporelings, fertile fronds growing on mature plants and the soil spore-bank are exterminated during seasonal fires, which negatively affects its reproductive cycle. After seasonal fires new fronds arise on the trunks in the following season, but frequent and prolonged fires as well as violent Jhum fires can completely destroy the *Brainea* population. If these factors persist much longer, the species may even be wiped out from India. Timely steps for its conservation are therefore an urgent priority.

As an ornamental plant, *B. insignis* has been introduced into gardens and to the nursery trade internationally for over a century[1,2,15]. However in India fern cultivation is still at a gestation stage and only a limited selection of exotic and some native species are available in the gardens or nurseries. Cultivation of *B. insignis* has been completely neglected in India, except at BSI Shillong.

All true tree ferns (species of *Cyathea* and *Cibotium* from India) are listed in CITES appendix[16,17], but this false tree fern is not listed as yet. Therefore it is proposed here to include it under various protection umbrellas. Keeping the above

facts in mind, an appeal is made here for the conservation of this regionally threatened species in its natural habitat (*in situ*) as well as in botanic and public gardens (*ex situ*), ensuring that the stock for cultivation is obtained from spore germination instead of wild extraction. Forest departments of the NE Indian states in which it occurs should also take necessary action for its *in situ* conservation, habitat restoration and a ban on overexploitation.

1. Hooker, W. J., *Hooker's J. Bot*., *Kew Gard. Misc*., 1853, **5**, 237–238.
2. Smith, J., *Catalogue of Ferns in the Royal Gardens at Kew*, HMSO, London, England, 1856.
3. Holttum, R. E., *A Revised Flora of Malaya*, Government Printing Press, Singapore, 1966, vol. 2.
4. Kramer, K. U., Chambers, T. C. and Hennipman, E., In *The Families and Genera of Vascular Plants* (ed. Kubitzki, K.), Springer-Verlag, 1990, vol. 5.
5. Fraser-Jenkins, C. R., *Bull. Natl. Mus. Nat. Sci., Tokyo*, *Ser. B*, 2012, **38**(4), 153–181.
6. Wang, C. J., Wan, J. Z., Zhang, Z. X. and Zhang, G. M., *Springer Plus*, 2016, **5**, 904; doi:10.1186/s40064-016-2588-4.
7. http://www.herbarium.gov.hk/PublicationsPreface.aspx (accessed on 10 October 2018).
8. Nayar, M. P. and Sastry, A. R. K., *Red Data Book of Indian Plants*, Botanical Survey of India, Kolkata, 1987–1990, vols 1–3.
9. Rao, C. K., Geetha, B. L. and Suresh, G., *Red List of Threatened Vascular Plant Species in India*, ENVIS, Botanical Survey of India, Kolkata, 2003.
10. Chandra, S., Fraser-Jenkins, C. R., Kumari, A. and Srivastava, A., *Taiwania*, 2008, **53**(2), 170–209.
11. Chandra, S. and Fraser-Jenkins, C. R., In *Perspectives in Pteridophytes* (eds Verma, S. C., Khullar, S. P. and Cheema, H. K.), Bishen Singh Mahendra Pal Singh, Dehra Dun, 2008. pp. 207–234.
12. Haridasan, K. *et al.*, *Curr. Sci.*, 2018, **114**(3), 512–518.
13. Beddome, R. H., *Handbook to the Ferns of British India, Ceylon and the Malay Peninsula*, Thacker Spink & Co, Madras, 1883.
14. Roy, P. S. *et al.*, *Curr. Sci.*, 2013, **105**(6), 774–780.
15. Ridley, H. N. and Main, T. W., *Agric. Bull. Straits Sattlem Fed. Malay States*, 1909, **8**(6), 282–297.
16. Oldfield, S., *International Trade in Tree-Ferns and Evaluation on the Application of CITES*, World Conservation Monitoring Centre, Cambridge, UK, 1995.
17. http://www.bsienvis.nic.in/Database/bsi_3949.aspx (accessed on 5 May 2018).

ACKNOWLEDGEMENT. We thank C. R. Fraser-Jenkins of Nepal for valuable suggestions.

Received 7 September 2018; revised accepted 26 November 2018

B. S. KHOLIA[1,*]
S. SHARMA[1]
B. K. SINHA[2]

[1]*Botanical Survey of India, Northern Regional Center, Dehradun 246 197, India*
[2]*Botanical Survey of India, Head Quarter, Kolkata 700 064, India*
**For correspondence.*
e-mail: bskholia_bsi@yaoo.co.in