4R Nutrient Management for Onion in India

By A. Thangasamy

The right source of nutrient for onion must consider the soil type and all the limiting nutrients in the soil.
Determining right rate depends on the growing season, yield target, and method of nutrient application.
Right timing of nutrients during active vegetative growth is critical to ensure high productivity and nutrient use efficiency.
Right method of nutrient application through drip fertigation seemed to be most promising for onion farmers.

Onion is an important commercial crop that is grown around the world and consumed in various forms. In India, it is cultivated as a vegetable, spice, or condiment. On a global scale, India ranks second in area and production, but the productivity of onion (15.9 t/ha) is below the world average (19.3 t/ha) (FAOSTAT, 2014). This mainly due to the use of traditional varieties, lack of appropriate water, nutrient management practices, and improper crop protection measures.

Onion is a highly nutrient responsive crop. Nutrient requirement varies with cultivars, yield potential, season, and location. In absence of proper guidance, farmers' generally practice perception-based fertilizer application, leading to the over or under use of plant nutrients. The steady depletion of native soil fertility and the occurrence of multiple nutrient deficiencies in farmers' fields, identified nutrient management as a key factor limiting sustainable onion production. The 4R Nutrient Stewardship approach to nutrient management considers the right fertilizer source in combination with the right application rate, timing, and placement. This is to produce the most economical outcome, in any given crop, in addition to providing desirable social and environmental benefits essential to sustainable agriculture (Bruulsema et al., 2009).

Dr. Thangasamy observing the onion growth at 36 DAT through drip fertigation method of fertilizer application.

Right Source

Onion responds to a wide range of fertilizers and those commonly applied include: urea, diammonium phosphate (DAP), ammonium sulphate [$(NH_4)_2SO_4$], single super phosphate (SSP), potassium chloride (KCl), potassium sulphate (K_2SO_4), gypsum (source of sulphur), elemental sulphur, and other fertilizer grades (e.g., 10:26:26, 20:20:0, 19:19:19, 16:8:24, etc.) as major sources of nutrients. The selection of the fertilizer source depends on soil type, soil characteristics, plant root system, and method of fertilizer application. Wherever fertilizers are applied through drip irrigation (fertigation), water soluble fertilizers such as urea and fertilizer grades such as 19:19:19 and 16:8:24, seemed to the best choice for onion. The above fertilizers can be applied either alone or mixed with other fertilizers before transplanting.

In addition to the above sources, the use of manures is suggested (Ngullie et al., 2011). However, their effectiveness is potentially limited by nutrient release patterns that often do not coordinate with crop demand, large variability in source quality, field distribution, and food safety. The yield of onion bulbs decreased by 30 to 45% with organic sources over conventional methods of production with inorganic fertilizers (Thangasamy et al., 2016). The integrated use of organic and inorganic fertilizers increased bulb production, improved biochemical quality and soil organic carbon status as compared to inorganic fertilizer alone (Thangasamy and Lawande, 2015). Given the good supply of quality manures, Ngullie et al. (2011) favoured the combined application of inorganic fertilizers and manures over sole application of either nutrient source. Contribution from other sources, such as irrigation water and native soil, may also be considered when developing nutrient management strategies for onion.

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; S = sulphur; Cu = copper; Fe = iron; Mn = manganese; Zn = zinc.

Right Rate

Onion requires a large quantity of plant nutrients compared to cereals and vegetables. Studies conducted at different locations in India showed that onion removes 2.1, 0.75, 2.2, and 0.28 kg N, P_2O_5, K_2O, and S (DOGR, 2015) to produce 1 t of

Table 1. Yield and nutrient uptake of onion varying with crop seasons and method of applications. Source: DOGR, 2015.

Yield/Nutrient uptake	Kharif NPK*	Kharif N**	Late kharif NPK*	Late kharif N**	Late kharif Broadcast	Rabi NPK*	Rabi N**	Rabi Broadcast
Yield, t/ha	20	16	43	36	36	43	42	41
N, kg/ha	73	66	80	86	83	97	89	95
P, kg/ha	14	13	18	19	17	25	24	18
K, kg/ha	74	71	74	73	71	87	74	72
S, kg/ha	22	20	14	10	12	25	20	20
Zn, g/ha	105	94	131	119	138	164	136	127
Cu, g/ha	45	37	59	52	54	65	65	58
Mn, g/ha	262	260	305	240	255	214	186	164
Fe, g/ha	980	899	2,094	1,907	1,987	907	824	849

*NPK fertilizer applied through fertigation
**N fertilizer applied through fertigation

bulb yield. These findings were similar to the reports of Dogliotti (2003) and Zhao et al. (2011) from other countries, which indicated that the nutrient requirement was more or less similar at varied locations and for different varieties. The yield potential and total nutrient requirement of onion crop varied with season, yield level, and method of application. Results in **Table 1** showed that bulb yield and nutrient requirement varied with cropping seasons, with significantly less productivity in kharif (18 t/ha) as compared to late kharif (38 t/ha) and rabi season (42 t/ha). Based on the results in **Table 1**, AINRPOG (2011) revised the nutrient recommendation of onion to 75:40:40:30 kg/ha N:P:K:S in kharif and 110:40:60:30 kg/ha N:P:K:S in rabi season,

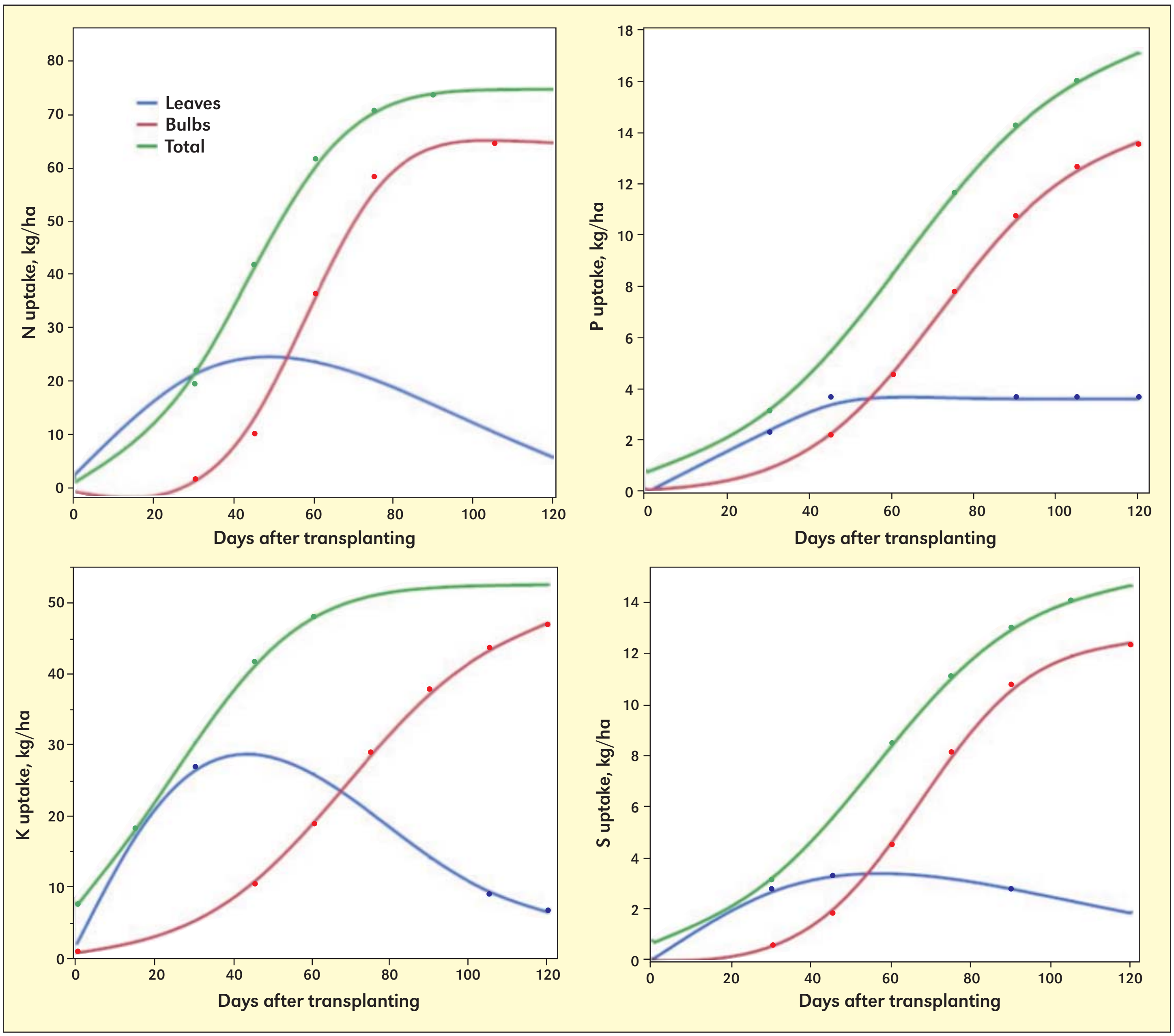

Figure 1. N, P, K, and S uptake pattern during onion growth period. (Thangasamy, 2016)

Table 2. Nutrient uptake of onion (cv. Bhima Kiran, bulb yield target, 45 t/ha). Source: Ganeshamurthy and Thangasamy (2016).

Parameters	Leaves	Bulbs	Total
Dry matter yield, kg/ha	709	3,604	4,313
Nutrient uptake			
N, kg/ha	6.1	74	80
P, kg/ha	0.5	15	16
K, kg/ha	16	53	68
S, kg/ha	1.7	13	15
Fe, g/ha	543	592	1,135
Zn, g/ha	17	90	108
Mn, g/ha	43	65	108
Cu, g/ha	2.7	11	14
B, g/ha	407	1,273	1,680

in addition to applying 75 kg/ha N through organic manures in both the seasons.

Excessive or inadequate rates of nutrient application affect onion yield. Palaniappan and Thangasamy (2015) reported an increase in collar and pseudo-stem thickness, occurrence of twin bulbs and bolters, and reduced storage quality with decreased onion bulb yield due to excessive rates of nutrient application. The total nutrient uptake in onion for a yield target of 45 t/ha (**Table 2**), indicated that onion accumulated 92, 96, 77, and 89% N, P, K, and S in bulbs. Ganeshamurthy and Thangasamy (2016) suggested that nutrient management for onion should consider replacing the quantity of nutrients removed through bulbs and recycling nutrients accumulated in the leaves through reincorporation of the leaves into soil after harvest. Sustainable onion production should aim at determining the right rate of nutrients considering the crop requirement based on yield target, growing season. and method of nutrient application.

Right Time

The timing of nutrient application in onion is governed by the nutrient uptake pattern during crop growth stages. N, P, K, and S are mobile in the plant system and nutrients accumulated in the leaves are remobilized and translocated to bulbs during bulb enlargement and maturity stages. Ensuring the rapid uptake of these nutrients during active vegetative growth stages through right timing of application is critical for onion production.

The NPKS uptake from planting to 15 days after transplanting (DAT) was low and coincides with establishment stage. Low nutrient uptake at initial stages could be due to slower adaptation of seedlings to their new environment. Excess application of fertilizers during this period may be leached beyond the root zone through irrigation water and become unavailable to plants. Thangasamy (2016) reported that the rate of total uptake of N and K increased rapidly from 15 DAT and reached maximum at 45 DAT, with peak uptake recorded during 33 to 40 DAT. The total peak uptake of P and S was observed during 45 to 50 DAT (**Figure 1**). The study indicated that the peak N, P, K, and S uptake occurs during 15 to 60 DAT, and fertilizers should be applied before 60 DAT for increasing bulb yield and nutrient use efficiency. Application of fertilizers after 60 DAT delayed bulb development, increased collar thickness, number of twin and multicentre bulbs, and reduced storage quality (Thangasamy, 2016).

Uptake of micronutrients such as Zn, Mn, and Cu in the leaves increased at faster rate and reached peak at 30 DAT

Dr. Thangasamy demonstrating the right rate of nutrient application to onion.

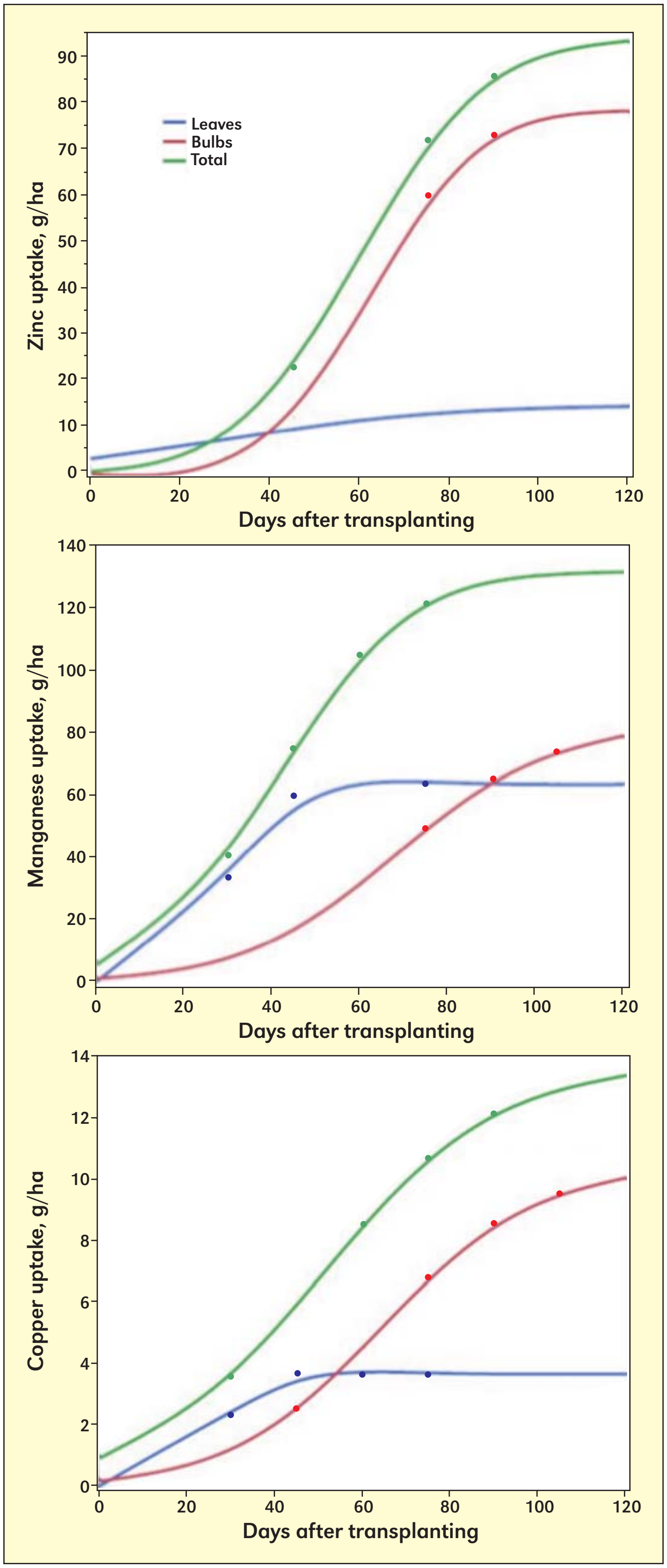

Figure 2. Zn, Mn, and Cu uptake pattern during onion growth period. (Thangasamy, 2016).

The right source of nutrients for onion.

(**Figure 2**), but decreased sharply at 60 DAT (Thangasamy, 2016). The total uptake by the onion plant and bulbs remained more or less same upto 90 DAT, indicating that Zn, Mn, and Cu accumulated after 60 days directly moved to the bulbs (**Figure 2**). Micronutrients (Zn, Mn, Cu, B, and Fe) are immobile in phloem and not remobilized and translocated to bulbs. Due to this, plants remove these micronutrients directly from soil through crop maturity to harvest. Deficiency of micronutrients at any point of time can reduce bulb yield, indicating that season long supply of micronutrients is essential for producing high bulb yield. Organic manures contain appreciable amounts of micronutrients and application of such sources can alleviate micronutrient deficiency during the entire crop growth.

Right Place

Onion has a shallow root system that is mainly distributed within the top 10 to 30 cm of soil. Being a closely spaced crop, fertilizer nutrients need to be applied near the root zone to increase the nutrient use efficiency. In general, fertilizers are applied through various methods including broadcasting, banding, fertigation, foliar application, and microinjection. **Table 1** showed that the application of NPK through drip system increased NPK uptake over application of N, through drip system and broadcasting method (DOGR, 2015). Rajput and Patel (2006) reported that application of N fertilizers through drip irrigation system increased the bulb yield significantly and reduced nitrate leaching to sub-surface soil. Dawelbeit and Ritcher (2004) observed that the drip fertigation system in onion produced higher yields compared to drip irrigation with fertilizer broadcasting. Other studies reported that N application through drip system, up to 70 days after transplanting, produced 22% higher bulb yield over broadcasting of fertilizers (NRCOG, 2006). This was compared to the flood irrigation system with broadcasting of fertilizers, which increased collar thickness and number of double bulbs (AINRPOG, 2015).

Summary

Implementation of improved nutrient management can not only improve onion yield, but also enhance nutrient use efficiency coupled with better economic returns to farmers while reducing environmental risks. The actual nutrient needs of onion largely depends on growing season, variety, yield goal, and soil fertility status. Appropriate fertilizer timing and placement must coincide with onion growth stages for maximum nutrient uptake, higher bulb yield and better quality. The 4R Nutrient Stewardship approach provides a framework to identify the best options to meet onion's nutrient demands. BC-SA

Dr. Thangasamy is Scientist (Soil Science) at ICAR-Indian Institute of Onion and Garlic Research, Pune, Maharashtra, India; E-mail:astsamy@yahoo.co.in.

References

AINRPOG. 2015. Annual report, Directorate of Onion and Garlic Research, Rajgurunagar. Pune.

Bruulsema, T., J. Lemunyon, and B. Herz. 2009. Crop Soils 42:13-18.

Dawelbeit, S. and C. Richter. 2004. Deutscher Tropentag, October 5-7, Berlin.

Dogliotti, S. 2003. Ph.D. Thesis, Wageningen University, Wageningen, The Netherlands.

DOGR. 2015. Directorate of Onion and Garlic Research, Rajgurunagar, Pune.

FAOSTAT. 2014. Comparison of onion productivity of India with world average. http://faostat.fao.org/beta/en/#compare.

Ganeshamurthy, A.N. and A. Thangasamy. 2016. *In* V. Mahajan, P.C. Tripathi, P.S. Srinivas, S.J. Gawande, S. Anandhan, A. Thangasamy, S.S. Gadge, and R.P Singh (eds). Souvenir and abstracts. 2nd National Symp on Edible Alliums: Challenges and strategies for sustainable production, Jalna, Maharashtra, November 7-9, 2016, P. 102.

Mishra, R.K., R.K. Jaiswal, D. Kumar, P.R. Saabale, and A. Singh. 2014. J. Plant Breeding and Crop Sci. 6(11):160-170.

Ngullie, E., V.B. Singh, A.K. Singh, and H. Singh. 2011. Better Crops, 95(1):7-9.

NRCOG. 2006. National Research Center for Onion and Garlic, Rajgurunagar, Pune.

Palaniappan, R. and A. Thangasamy. 2015. ICAR-DKMA, Indian Council of Agricultural Research, New Delhi.

Rajput, T.B.S. and N. Patel. 2006. J. Agr. Water Management, 79:293-311.

Thangasamy, A. and K.E. Lawande. 2015. Indian J. Horticulture, 72:347-352.

Thangasamy, A. 2016. Communications in Soil Science and Plant Analysis, 47:246-254.

Thangasamy, A., G. Kalyani, T.P. Shabeer Ahammed, R.S. Kavith, K. Banerjee, V. Sankar, and M.C. Kisho. 2016. *In* V. Mahajan, P.C. Tripathi, P.S. Srinivas, S.J. Gawande, S. Anandhan, A. Thangasamy, S.S. Gadge, and R.P. Singh (eds). Souvenir and abstracts. 2nd National Symposium on Edible Alliums: Challenges and strategies for sustainable production, Jalna, Maharashtra, November 7-9, 2016, P.228.

Zhao, K., K. Xu, N. Xu, and Y.G. Wang. 2011. Plant Nutrition and Fertilizer Science, 15:241-246.

Update on IPNI South Asia Program Staff

Recent IPNI staff appointments include Dr. Kaushik Majumdar, Vice President, Asia, Africa & Middle East Group (left) and Dr. T. Satyanarayana, Director, South Asia Program (right).

Dr. T. Satyanarayana was named Director of the IPNI South Asia program effective July 1, 2016. Dr. Kaushik Majumdar, who had previously served as Program Director, has been named IPNI Vice President Asia, Africa & Middle East programs effective July 1, 2016. Dr. Majumdar has replaced Dr. Adrian Johnston, past Vice President, Asia and Africa. The program office remains in Gurgaon, India. The South Asia region includes India, Pakistan, Bangladesh, Nepal, and Sri Lanka.

"We expect a smooth transition during this time and plan to maintain positive and productive programs in this important region," noted IPNI President Dr. Terry Roberts. "Dr. Majumdar has accomplished significant and lasting advances for the agriculture and people of all the areas he served. His positive influence extended to our programs worldwide." He added, "We are confident Dr. Satyanarayana will move the South Asia program forward as we work to improve nutrient management in this region."

"Because Dr. Satyanarayana has the benefit of more than 7 years' experience as Deputy Director, IPNI programs will continue to progress," expressed Dr. Johnston. Dr. Satyanarayana, a native of Yanam, Pondicherry, joined the IPNI staff in 2008. He completed undergraduate studies at Pandit Jawaharlal Nehru College of Agriculture (PAJANCOA), Karaikal in 1998, then earning his M.Sc. degree in 2001 at Dr. Y.S. Parmar University of Horticulture & Forestry (YSPUH&F), Nauni, Solan in Himachal Pradesh. Dr. Satyanarayana completed his Ph.D. program at Indian Agricultural Research Institute (IARI), New Delhi during 2005.

In 1999, Dr. Majumdar joined the staff of the Potash & Phosphate Institute (PPI), the predecessor of IPNI. A native of West Bengal, he completed undergraduate training in agriculture at the Visva Bharati University before earning his M.Sc. (Ag) from B.C.K.V Agricultural University in 1987 and his Ph.D. at the Rutgers University in 1993. He later held important responsibilities with the Potash Research Institute of India in Gurgaon working on potassium mineralogy of Indian soils. BC-SA