Strategic networking for global rice genetic advancement

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A network approach for boosting efficiency in agricultural research has been widely accepted by various international and national research organizations, because of the wide-ranging benefits, most important of which is the acceleration of the transfer of technology to the farmer.

Rice, the world's foremost food crop derived from a wild progenitor was born as a semi-aquatic plant in the hot humid tropics with a strong monsoon pattern. However, it has gradually forayed into a diversity of habitats, breaking the environmental, as well as geographical barriers, and encompassing agroecosystems that reflect a wide range of water and temperature regimes, altitude level, and edaphic properties. Its cultivation extends to latitudes that circumscribe the tropical and semi temperate environments, ranging from 40˚ south in central Argentina to 51˚ north in north-eastern China. Thus, rice is grown in more diverse environmental conditions than any other major crop. The flip side of such an ecological sprawl is its face-off with a plethora of biotic and abiotic stresses, posing a strong challenge for rice genetic improvement.

Prior to the Green Revolution era, rice scientists in the developing countries used to work in scientific isolation with limited experimental materials, the paucity of research facilities including literature, inadequate training, and lack off opportunities to interact with fellow rice scientists at other research centers. Moreover, the experimental stations in several instances were not quite representative of the ecosystems they were purported to serve. Progress in rice yields and thereby its production thus remained at a pace that allowed it to be overrun by the rate of population growth. That was the post-world war II scenario in several developing countries, where rice is the main staple, and that situation has raised concerns and awareness at both national and international levels.

Because of the geographical and ecological diversity, structured networking of rice breeding programs across the world is strategically vital for global genetic improvement of rice for cultivation in different ecosystems and raising the world output of the grain. Such an approach is also effective within national programs with wide-ranging rice cultural systems. Networks are inexpensive and at the same time are effective catalysts for research. Collaborative networks help to spread useful research results among regions with similar agro-ecologies.

Some national programs that gained experience in rice research turned towards pooling up their resources for a nationwide cooperative crop improvement program. An excellent example is the All India Coordinated Rice Improvement Project (AICRIP), the largest national rice research network, established by the Indian Council of Agricultural Research (ICAR) in 1965. AICRIP has successfully brought together scientists working at over 100 research stations across different states, and through its exchange platform, forged national cooperation in research on genetic enhancement, nutrition management, and protection against major insects and pathogens.

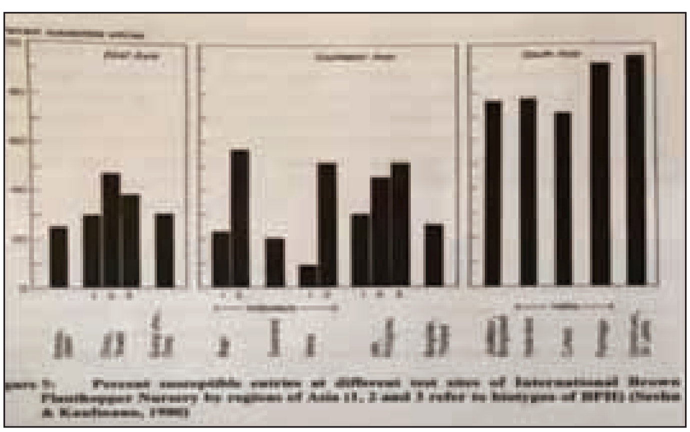
Historically, at an international level, a limited and informal exchange of plant germplasm among scientists from a few countries with common interest took place before World War II. The international Wheat Stem Rust Nursery established by the United States Department of Agriculture (USDA) in 1950 was the first formal and systematic nursery to transcend the national borders. This was necessitated by a serious outbreak of a new race of stem rust in the 1950s. The Rice Blast Nursery organized by IRRI in 1963 and the Spring Wheat Yield Nursery organized by the

International Maize and Wheat Improvement Center (CIMMYT) in 1964 represents the first efforts by the International Agricultural Research Centers (IARCs) to work cooperatively with the National Agricultural Research & Education System (NARES).

The establishment of a series of IARCs under the aegis of the Consultative Group of International Agricultural Research Centers (CGIAR) was a quintessential response to the emerging food crisis in the early sixties of the last century in the developing world. The first among those was the International Rice Research Institute (IRRI), originally funded by the Rockefeller and Ford Foundations, and established in the Philippines in 1960. IRRI in its first decade primarily focused on research and related activities at its center, which resulted among other things in the development of a high-yielding semi-dwarf variety, IR8 (IRRI's flagship); establishment of a gene bank; development of screening techniques for resistance to major diseases and insects; establishment of a comprehensive training program, setting up of a library with world's largest collection of rice literature, and so on. To buttress the varietal improvement research, a multidisciplinary 'Genetic Evaluation, and Utilization (GEU)' program was introduced in IRRI's second decade. Once equipped with the necessary research wherewithal, and having acquired the capacity to take a lead role, IRRI initiated the establishment of various research networks with the cooperation and commitment of the NARES. The International Rice Testing Program (IRTP), which was subsequently renamed as International Network for Genetic Evaluation of Rice (INGER) was the first among those networks. Initiation of the networks also reflects on the concern and realization of IRRI, that while it has a global mandate for rice improvement, its research facilities are located in but one of the several rice growing environments. For example, gall midge, a major insect pest in parts of South Asia does not occur in the Philippines, which limits IRRI's capabilities to carry research related to that pest without collaboration with scientists in the concerned national programs. Similar is the case with problems such as deepwater, low temperature, acid sulphate soils, etc. Thus, networking involving NARES has become imperative for global rice improvement.

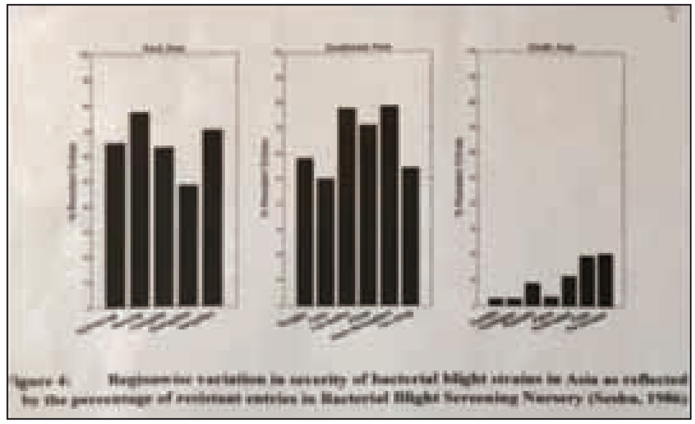
INGER established in 1975 is the world's largest agricultural research network participated by more than 75 countries in Asia, Africa, Latin America, the Caribbean, and Oceania. When the program started in 1975, over 80% of the test entries came from IRRI and the remaining from the NARES. In course of ten years after the start, the proportion of sources of entries has significantly changed, with over 65% originating from NARES and 35% from IARCs, primarily from IRRI. That reflects on the strength gained by the national breeding programs, as resulting from the active participation of its scientists in INGER, and in the network-sponsored joint site visits, workshops, and training programs, with an opportunity to interact with fellow rice scientists from other countries. Thus, with the strengthening of capabilities and institution building, the breeding researches of the NARES progressed from dependency to interdependency. NARES materials get DNA fingerprinted to alleviate their concerns relating to intellectual property rights.

Through the cooperative exchange and evaluation of promising breeding lines, as of date, a little over 1200 INGER-tested lines were directly released as varieties to farmers in 74 countries. Further, several entries were used in crosses as genetic donors for important traits, and over 1000 elite lines from those progenies were released as varieties in 21 countries. Some entries have been successfully utilized as restorers in hybrid rice programs. For example, 36 hybrids released in India and 34 in China, owe their restorer source to INGER. The multilocation screening trials have provided valuable information on pathogenic variation in major disease-causing organisms, and biotype variation in severe crop-damaging insect pests. Various aspects of the interaction of rice with weather variables have



Regional Variation in Response to BPH

been elucidated through specially designed studies conducted at selected representative INGER test sites in different countries.



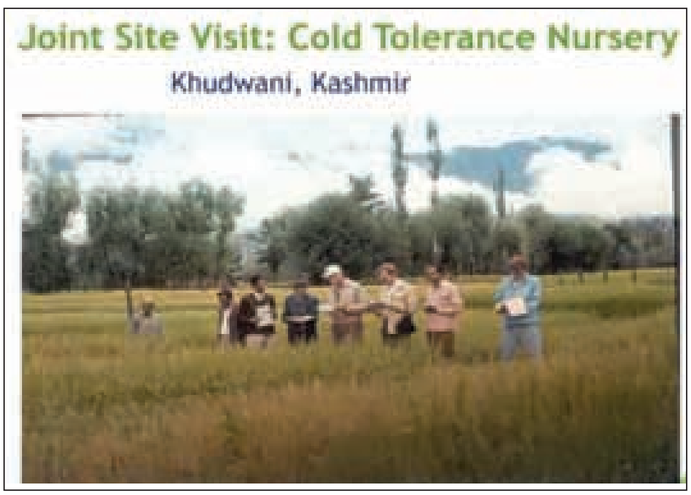
Regional Variation in Response to Bacterial Blight

From 1975, when INGER was established to date, the global rice production increased by about 30% (Source: Statista), whereas the acreage during that period increased by only 12%. The major contribution to the increase is from the improved varieties. INGER-tested and released varieties caused a significant part of that increase, as indicated by the number of varieties released through that mechanism. Two Yale University economists, Robert Evenson and Douglas Gollin studied 591 INGER-derived high-yielding and pest-resistant varieties released in 64 countries. They estimated that each released variety contributes annually USD 2.5 million to the global economy at 1990's costs. Using that old figure on current data, the 1,200 INGER-derived varieties contribute annually USD 2.8 billion to the world economy.

According to Gelia Castillo, a noted social scientist from the Philippines, rice seeds share a common food value and speak a common language that transcends politics, geography, and culture. In Africa, for instance, INGER helped break a barrier in rice science between English and French-speaking countries. She maintains that "INGER is a beautiful illustration of humanity working together for our common future in a world filled with social conflicts, tribal wars, and fierce competition over the control of natural resources" (Rice Today, 2015).

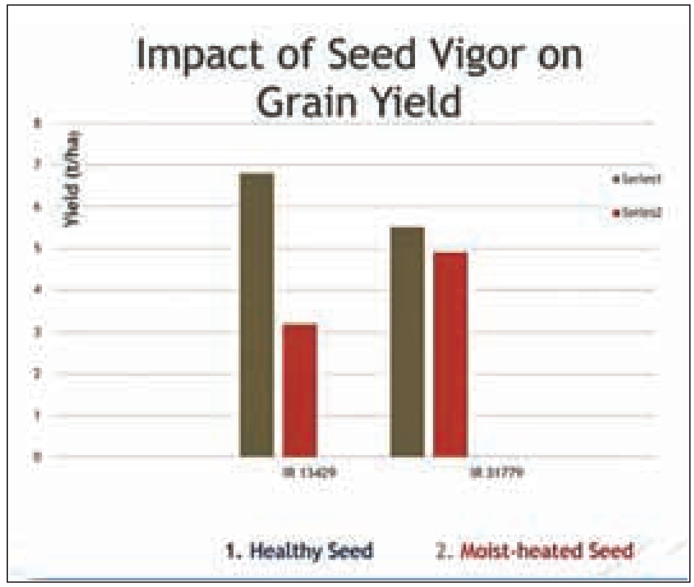
Past accomplishments, however, do not ensure the network to sustain its relevance to the national programs, unless it is kept dynamic, and the emerging needs are addressed with a rational and pragmatic approach. In this context, I have summarized my thoughts for updating the program, as follows:

INGER has been established over a while as a strong cooperative platform for rice genetic improvement through the concerted efforts of the world community of rice scientists, breaking down social, cultural, and political barriers. Every effort should be made to maintain and nurture such a well-proven excellent mechanism through both technical prowess and financial sustainability to uphold and validate the prodigious efforts that have gone into its establishment. In the larger interests of the world's food security, the concerned research institutions and funding agencies should take cognizance of the need to enable INGER to maintain its dynamism in effectively addressing the changing needs of rice improvement. The cooperative structure so carefully crafted should be efficiently utilized for all future challenges.



Several national programs have gained adequate strength in terms of research capabilities and facilities, and thus are in a position now to share some of the financial and organizational responsibilities to carry forward the successful network program. Delegation and assumption of technical responsibilities should be based on the respective ecosystem advantages with attending stresses. A comprehensive discussion with the concerned NARES will help set the stage for an effective and unhampered continuation of the network to meet the needs arising out of the new challenges.

Rice breeding programs hitherto have mostly been focused on traits relating to the growth stages from seeding to harvest, assuming the post-harvest care to be a function of crop husbandry. However, significant genetic variation exists in respect of important post-harvest traits, such as seed vigour and threshability. Thus, entries in observation and yield trials must be characterized for those traits and their values included in the data collection, as they have a recognizable influence on the ultimate yield. The yield figures as recorded now are not reflective of the realizable yields after postharvest operations, which may obliterate the varietal rankings.



Shortage of water is probably the single most significant challenge that will confront the world's farmers in the coming years. Rice is a water guzzler when compared to other crops. It uses up to two to three times more water than other food crops such as maize or wheat and consumes around 30% of the freshwater used for crops worldwide. Thus, there is an urgent need to regulate the water footprints contributed by rice culture. While scientists from relevant disciplines have been pursuing research toward this goal, INGER should do its part by capitalizing on its cooperative base to evaluate varieties at selected representative sites for their performance under a range of hydrological situations. Carefully planned testing should enable identifying varieties with good performance under an optimal input of irrigation water. On the other hand, efforts should be intensified to screen for tolerance to water stress. Also, systematic monitoring should be done to elucidate the utilization of several INGER entries identified in the past for drought tolerance, and promising progenies from those breeding efforts have to be evaluated by the INGER system.

Yet another important area necessitating breeding inputs is to determine the genetic variation in the efficiency of utilization of the native and applied nutrients. This would significantly supplement the management methodologies recommended by the agronomists.

Issues like climate change must be taken up more systematically from the genetic angle, through the INGER mechanism.

Cropping-systems trials at a given test site need to be linked appropriately with INGER trials to derive maximum benefits from the combined information in choosing the more productive location- and system- based varieties, that would provide a holistic advantage to the farmer.

An important suggestion relates to the gene bank. Through painstaking and sustained efforts, substantial number of traditional varieties and landraces, possessing a repertoire of treasured genes have been fingerprinted and characterized at IRRI for morphological and physiological traits, and reactions to major diseases and insect pests. However, it may be noted that the data gathered pertains to the environment of IRRI's home base. The gene bank is meant for the benefit of the entire rice-growing world. INGER screening trials have brought out the differential reactions of varieties to major stresses in different environments. Thus, the data collected at IRRI may not have relevance to other countries. The gene bank's varietal characterization chart should reflect the differential reactions where they exist, for it to serve its global mandate. Therefore, it is essential to initiate a special screening nursery for the traditional germplasm for testing at selected hotspots identified by INGER. Since it involves a large-scale planning for screening in batches of the voluminous collection and analysing the data systematically, external funding is very essential to avoid financial burden on the cooperating centers.

Rice, as stated earlier, has evolved through very high levels of adaptation to various ecological habitats and has its cultivation spread across the continents. Genetic improvement remains a challenge when trying to maintain harmony between rice and its environment. Thus, it is of paramount importance to have active cooperation of scientists within and among the rice-growing countries to facilitate pooling and sharing of research materials and expertise through a structured network mechanism. Valuable bonuses from such an approach are savings in time and monetary inputs, and more importantly, acceleration of the transfer of technology to the farmer. The pooling of materials from diverse sources also promotes the much-needed genetic diversity. While the agro-ecological diversity of rice crop poses a 'challenge' for varietal improvement, geographical diversity provides an 'opportunity' for cooperation. The rice genetic improvement network has been founded on this sanguine concept. Individual strengths of the national systems may vary, but their collective strength is formidable. A meaningful fusion of those complementary strengths has powered INGER to effectively serve the needs of the various participating countries in fostering location-specific genetic enhancement of rice. INGER thus has proved to be an epitome of veritable synergy and signifies the power of cooperation. The incontrovertible benefits such as efficacy in the use of resources, reduced costs, and saving on time, render the network concept continue to permeate various aspects of agricultural research for the betterment of the farmers and consumers. In this context, the funding agencies need to take cognizance of the fact that their financial support to cooperative networks such as INGER would yield very significant returns in terms of the world's food security, paying the value of their investments.

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Let me express my sincere thanks to the Society for Advancement of Rice Research (SARR) and the Indian Institute of Rice Research (IIRR) for the excellent opportunity given to me to share with the rice research community, my viewpoints as cognizant of networking. It is indeed a great pleasure and privilege for me to deliver the 'SVS Shastry Memorial Lecture'. I have chosen a subject that is close to the heart of the departed rice scientist. In articulating the content of the above article, I have drawn upon my years of experience in networking at both national and international levels. I was with AICRIP (ICAR) network for 10 years; had helped organize and coordinate the INGER network program at IRRI

for 20 years; had established and directed the Fish Genetic Improvement Network (INGA) for two years at World Fish Center; and served as a consultant to West Africa Rice Research and Development Network (WARDA), headquartered in Liberia, during its initial stage of establishment in the early seventies. Thus, I earnestly hope that my article will trigger enough interest in my rice research colleagues, and I would thankfully welcome any suggestions.

I now feel it an immense pleasure and duty to script a few lines about my erstwhile friend and colleague, Dr. Sishta Venkata Sitarama Shastry: I had a long professional association with Dr. Shastry, which dates back to 1955 when I joined the Botany Department at Central Rice Research Institute (CRRI), Cuttack, where he was already a staff member for three years. We had an overlap of one year before he proceeded to the USA for higher studies. Since then, our professional, as well as, social interactions gathered mileage and flourished all through his life. At CRRI (present National Rice Research Institute (NRRI), Cuttack), both of us were in the Japonica x indica Hybridization Scheme. The variety, Masoori was one of the well-known products of that program. After returning from the USA, Dr. Shastry joined IARI, where he pursued research on rice cytology. At the same time, I was involved in research on Cytogenetics of interspecific hybrids in Oryza. We had a good collection of wild relatives of rice, as well as, wild species of Oryza at CRRI, which formed the experimental material for my research. With the techniques then available, rice was relatively less amenable for distinct cytomorphological characterization of full-length pachytene chromosomes. Our parallel efforts, however, provided an opportunity for closer interactions through the exchange of ideas, visits, and materials, leading to useful results in an area of rice research that remained unchartered until that time. After CRRI, our professional paths crossed again, when we were brought together at AICRIP in 1966, where he directed the Project, and I was heading the breeding program. We spent ten years together with commitment to that ICAR's flagship coordinated research endeavour. The AICRIP chapter in my research career was most memorable because that coincided with the launch of the Green Revolution. Recognition of the impact of physiologically efficient plant architecture on grain yields, opened up new vistas for genetic improvement of rice, through the development of a series of semidwarf cultivars. With no physical facilities and limited fiscal support, we initiated the coordination program. Dr. Shastry, Dr. Freeman, and I were sharing a single room in the Sorghum Center (PIRRCOM). The seed of important breeding lines was also stored in the same room. The paucity of facilities did not come in the way of our research efforts, having been engulfed by the excitement and determination driven by the promise of new technology. An excellent team spirit forged by Dr. Shastry galvanized our efforts. Here I must make a mention of the deep commitment and valuable inputs of Dr. Freeman to the program, which acted complementary to the able leadership provided by Dr. Shastry. When the first batch of HYV's resulting from our breeding efforts (Jaya, Sona, Rasi, etc.) made a mark in All-India testing, ICAR provided funds for physical facilities and research staff. Dr. Shastry, Dr. Freeman, and I, in our internal dialogues often used to refer to AICRIP as '66 spirit'. The Deputy Chairman of Planning Commission during his visit to AICRIP in early 1976, stated in the guest book, 'few staff members, yet very significant output'. That was a great tribute to the program driven by team spirit.

In 1975, Dr. Shastry left AICRIP on an FAO assignment, when I took charge of the Institute for some months. I also left AICRIP in 1976 on an invitation from IRRI to join its staff. I took up a position at IRRI as Rice Breeder and Global Coordinator of IRTP/INGER. After spending two years at FAO, Dr. Shastry joined IITA in Nigeria, as Director of Research, where he actively pursued the Rice research program. As Global Coordinator of INGER, I had a regional unit for West Africa, headquartered at IITA. Thus our professional interactions continued as staff members of different CGIAR centers, but with common involvement in rice. After his retirement, I had the privilege of having Dr. Shastry as a consultant for INGER on two or three occasions. Even after both of us retired, we had been periodically communicating with each other relative to various aspects of rice research. The keen interest he had evinced in rice in our most recent interactions just a few months before he passed away, was no less intense than those we used to have when we were actively working together at AICRIP. Our professional association is well reflected by the fact, that we had several joint research publications resonating with the Green Revolution era.*

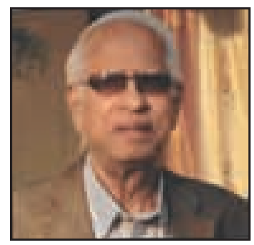
AICRIP Review Meeting, 1968

Farewell to Dr. and Mrs. SVS Shastry, 1975
When Departing AICRIP on FAO Assignment

Dr. Shastry's research contributions to rice improvement are well known and were duly recognized with distinguished awards. However, I wish to add my impressions emanating from long years of active association with him. Dr. Shastry's scholarly pre-eminence reflects a combination of a high level of intelligence and an extraordinary memory. He never had room for nonchalance in his work aptitude. He had a unique personality that was well comprehensible to many of his colleagues, while remained abstruse for others. He had the habit of being forthright and candid in speaking his mind, without bringing into play the art of diplomacy. Even when facing an adverse comment, he used to have an apt and measured response, rather than getting impulsive. I was always impressed with his quick grasp and critical analysis during our research deliberations, which trait used to bolster his efforts in formulating research plans that were both logical and scientific. His professional competence may well be described as an amalgam of scientific calibre and leadership acumen. It was that leverage of his, which proved pivotal for the success of AICRIP.

Dr. Shastry had an ardent passion for mythological stage-plays in Telugu. He was an excellent bridge player. One of his fascinating hobbies was cooking. Our family had the good fortune of enjoying his culinary skills, when he took command of the kitchen in our residence in Ithaca, NY, during his visit to Cornell University in 1984. I take great pride in being a close friend and associate of Dr. Shastry. May his soul rest in peace!!

Dr. Durvasula Venkata Seshu



Dr. Durvasula Venkata Seshu (Dr. D.V. Seshu) was born on 19 April 1933 in Jeypore, Odisha. He obtained his B.Sc. degree from Andhra University (1952), M.Sc. (1954) and Ph.D. in Agricultural Botany (1964) from Utkal University (now Ravenshaw University). He was awarded with Rockefeller Foundation Fellowship for Post-Doctoral Research on Rice breeding at IRRI during 1967-68. He underwent a Senior Research Management Training organized by O'Hare Association, USA.

Dr. Seshu had more than 40 years of research experience on Rice, and three years on Fish. He served with the Indian Council of Agricultural Research (CRRI & AICRIP) for over 20 years (1955-76) as Rice Breeder and Geneticist. He was invited by the International Rice Research Institute (IRRI) to join its staff as Rice Breeder in 1976. He established and served as Global Coordinator of the highly successful International Network on Genetic Evaluation of Rice (INGER) from 1976-95. Recognizing the success of INGER, he was invited to establish and direct an International Network on Genetics of Aquaculture (INGA) by the World Fish Center. He was Adjunct Professor of Cornell University, USA, 1983-86 and Visiting Professor of University of Philippines, 1977-93.

As a Rice Scientist of the ICAR for over 20 years, Dr. Seshu made significant contributions to the Green Revolution in rice in India through providing inputs to development of early generation modern varieties (such as Jaya, Sona, Phalguna, Prakash, Rasi etc.), and through painstaking data analysis of nationwide coordinated trials and identification of location-specific elite varieties for different states. These varieties led to a three-fold increase in the rice production in India. Drought-tolerant Rasi was released in countries outside India also. Sona gave rise to the popular rice variety, Sona-Masoori. Genetic studies carried out by Dr. Seshu have greatly assisted in developing rice varieties resistant to major biotic and abiotic stresses.

As an International Scientist and Global Coordinator of INGER network, Dr. Seshu promoted international cooperation in agricultural research by bringing together scientists from more than 75 countries with different cultural, ethnic and political backgrounds, and encouraging them to exchange and evaluate their promising varieties and share their test results. The leadership provided by Dr. Seshu led to the release of more than thousand rice varieties for different ecosystems in 74 countries including India. As a result, the global rice production has increased by 30% from 1975 to date, while the area increased only by 12% during that period. Under the guidance of Dr. Seshu, INGER established itself as world's most successful and largest agricultural research network. Millions of farmers across the world were benefitted by the network through availability of improved rice varieties tolerant to various pathological and physiological stresses. INGER under his direction was given a CGIAR award.

Dr. Seshu established a very high quality Seed Processing and Research Laboratory at IRRI. His major contributions to Rice seed research include identification of biochemical markers for high protein content, and for salt and low temperature tolerance. When the prestigious 'Seed Science Research' journal was launched in UK in 1992, he was invited to present a paper on 'Mechanism of Rice Seed Dormancy' for publication in the inaugural journal.

Dr. Seshu was actively involved in climate change issues and served on several international panels on the subject. He was appointed as a Member of the Scientific Panel of the Secretary-General of the United Nations to study the climatic effects of nuclear war. He was a special invitee to International dialogue on Global Climatic Change sponsored by National Governors' Association, USA held at New York (Feb. 1989) and to the Global Forum on Environment and Development for Survival held at Moscow (Jan.1990).

Dr. Seshu served as a consultant on various occasions to International organizations such as UNDP and FAO. He served as a member of the Research Advisory committees of DRR and NBPGR. He is a Fellow / Member of various international professional societies. He served as a Chairman of the organizing committee for three International Rice Conferences at IRRI. He was invited as a Keynote speaker at a major International conference organized by the Asian Vegetable Research Institute in Taiwan in 1982. He traveled to more than seventy countries in his professional capacity. Dr. Seshu served as a research guide for several students from various countries and universities for their Ph.D. and MS degrees. He published more than 150 research papers in reputed journals, authored nine Technical bulletins and three books. A rice variety has been named in as SESHU in recognition of his breeding contributions. He received citations of honor from China and South Korea.