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Plant Genetic Resources Network in India

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India holds an important position in the international network of plant genetic resources, being a seat of origin and diversification for several old and new world crops. Besides, it has a rich and unique flora. About 160 species of crop plants and 320 of wild related types occur in the Indian gene centre with rich diversity in rice, sugarcane, citrus, mango, banana, egg plant, ridge gourd, bitter gourd, okra, cucumber, pigeonpea, cowpea, mung bean, urad bean, rice bean, moth bean, jute, tree cotton, oilseed Brassicae, safflower, sesame, spices and condiments and tuber crops such as taros and yams.

The National Bureau of Plant Genetic Resources established in 1976 with its 10 centres, coordinates activities in collection, exchange, evaluation, maintenance, documentation and conservation of plant genetic resources in the national and international context. Thus, it has linkages with crop-based ICAR institutes, agricultural universities and with international agricultural research centres and several regional organisations. The objectives and achievements of the Bureau, as a nodal agency in this field, are highlighted. Emphasis is also laid on the recent national and international developments and future perspectives are discussed.

Plant Genetic resources are the foundation of any crop improvement process. They need to be conserved in the interest of human welfare. Concern for the collection, evaluation, utilisation and conservation of these resources has been expressed in the recent past throughout the world. Man's intervention with nature is resulting in elimination of several useful plant species/forms. Thus, conservation of these resources is of paramount importance.

INDIAN GENE CENTRE

Indian gene centre holds an important position in the international network of plant genetic resources mainly on account of two factors. Firstly, India is one of the eight primary centres of origin/crop diversity as recognised by Vavilov (1949-50). Secondly, India took an early initiative to embark upon plant introduction and collection activities. Moreover, the Indian sub-continent is also considered to be an important cradle of agriculture.

Zeven and de Wet (1982) considered that nearly 2,400 plant species of economic importance could be accounted for in 12 mega gene centres/regions of diversity. Of these 160 species belong to the Indian Centre of diversity, besides

320 wild relatives and related species (Arora and Nayar, 1984). However, in the global context, where about 600 major and minor food and fodder crop plants are presently being utilised, only about 30 species are considered to be most important (Harlan, 1975).

The genetic resources of the Indian Gene centre are distributed in eight phyto-geographical/agro-ecological zones and these exhibit considerable preponderance of variable forms/land-races/primitive types in different crops in cereals, millets, legumes, vegetables, fruits, oil seeds, fibres, sugar yielding types, spices and condiments and others. The important crops in which rich landrace diversity exists include *Oryza sativa* var. *indica* and several wild *Oryza* species, *Saccharum officinarum* and allied genera, *Citrus* spp., *Musa* spp., *Mangifera indica* and other species, jackfruit, *Solanum* spp., cucumber, ridge gourd, bitter gourd, okra, oilseed Brassicae, sesame, safflower, mung bean, urad bean, rice bean, moth bean, pigeonpea, cowpea, jute, tree cotton, several spices and condiments, taros and yams.

NATIONAL BUREAU OF PLANT GENETIC RESOURCES

The Division of Plant Introduction, Indian Agricultural Research Institute, New Delhi, played an important role and made highly valuable contributions in the 1960s through the introduction and collection of plant genetic resources. However, it was mainly after the creation of the National Bureau of Plant Genetic Resources (NBPGR) in 1976 that activities relating to plant genetic resources received required impetus.

The National Bureau of Plant Genetic Resources is located on the campus of the Indian Agricultural Research Institute (IARI), under the aegis of the Indian Council of Agricultural Research (ICAR). At its headquarters, NBPGR is organised into five Divisions, (1) Germplasm Exchange, (2) Plant Quarantine, (3) Plant Exploration and Collection, (4) Germplasm Evaluation, and (5) Germplasm Conservation. Besides, a special project entitled 'National Facility for Plant Tissue Culture Repository' (NFPTCR) was established in 1986 with the financial support by the Department of Biotechnology. At its headquarters, the Bureau has main administrative offices, laboratories, long-term conservation facilities as well as Quarantine Isolation Nursery. An experimental farm of 40 hectares is located at Issapur, about 40 km. from the headquarters. In addition, the NBPGR has five regional stations in different agro-climatic zones, each being headed by a Senior Scientist (Botanist). These are at Shimla (temperate north western Himalayan belt), Jodhpur (arid zone), Akola (semi-arid region), Trichur (humid tropical zone) and Shillong (north eastern sub-temperate/sub-tropical humid region). Ten plant exploration base centres have also been created at each of these regional stations and also at New Delhi, Bhowali, Ranchi, Cuttack and Hyderabad. Two more exploration base centres are being established, one at Srinagar (Jammu & Kashmir) for the temperate and alpine regions and another at Port Blair in the Andaman and Nicobar Islands. The Bureau presently operates with a total strength of 542 staff (scientific–151, technical–108 and others–283).

Three All-India Coordinated Projects are also located at NBPGR headquarters. These include; (1) All India Coordinated Project on Medicinal and Aromatic Plants, (2) All-India Coordinated Project on Under-utilised and Under-exploited Plants and (3) All-India Coordinated Project on Guar (cluster bean).

The main objectives of NBPGR are: (a) Introduction and exchange of germplasm from national/international organisations under strict phytosanitary conditions and quarantine control, (b) To undertake and coordinate national and international explorations, evaluate/characterise and document the germplasm and to coordinate these activities with crop institutes, coordinated projects, agricultural universities, international institutes, (c) To conserve germplasm collections for medium-term and long-term storage (base collection) in the National Gene Bank as well as in the National Plant Tissue Culture Repository, and (d) To impart training in the field of plant genetic resources and associated disciplines.

SOME ACHIEVEMENTS

(i) *Plant exploration and germplasm collection*

National Bureau of Plant Genetic Resources executed effectively several region-specific, multi-crop collection and crop specific missions and potential genetic variability was captured. Well over 50,000 germplasm accessions have been assembled in agri-horticultural crops (Paroda and Arora, 1986). During the past one decade (1976-87), the Bureau successfully organised joint foreign expeditions in India. The important ones among these include Indo-Japanese expedition for minor millet germplasm (1985 and 1987), Indo-Australian expedition (1984) for collection of wild forage and legumes from black, heavy clay and acidic soils in central and peninsular India and NBPGR-IRRI joint expedition in the western Ghats, India, for collection of wild *Oryza* species. Explorations have also been undertaken by Bureau's scientists in other countries viz. Malawi, Zambia, Ethiopia, Sudan, Kenya, Mali and Nigeria in Africa and in the Maldives.

(ii) *Introduction and exchange*

Introduction and exchange of germplasm has received considerable impetus on account of established linkages with over 80 countries as well as with several CGIAR supported international institutes like IRRI (Philippines), CIMMYT (Mexico), ICARDA (Syria), CIP (Peru), CIAT (Colombia), ICRISAT (India), IBPGR (Italy), etc. Besides, germplasm exchanges have taken place between India and the USDA (USA), CSIRO (Australia), AVRDC (Taiwan), INTSOY (USA), VIR (USSR), INRA (France) and several others. The exchange of genetic resources during 1976-86 included 81,472 introductions/accessions.

(iii) *Quarantine*

The Bureau plays a significant role as far as quarantine activities for research materials are concerned since the Plant Protection Adviser, Government of India has delegated this authority to NBPGR. The Division of Plant Quarantine, after interception, tries to salvage the valuable germplasm. NBPGR also provides

quarantine services to ICRISAT for germplasm exchange at the global level. It also deals with the trial materials received from CGIAR Centres such as IRRI, CIMMYT, CIP, CIAT, ICARDA, etc.

The exchange of seeds/plant propagules on a global basis has resulted in the movement of pests/pathogens from their native habitats to the newer areas/locations. The Bureau has played a very effective role in plant quarantine service and during 1976-86, a wide variety of agri-horticultural crops (5,38,900 samples) were introduced into India. Several important exotic insect pests, nematodes and pathogens were also intercepted. Some of the important ones include: Insects—*Acanthoscelides obtectus* (bruchid on cowpea and pigeonpea), *Specularius erythreus* (bruchid on *Vigna radiata* and red gram), *Cydia* (*Carpocapsa*) *pomonella* (codling moth on walnut); Nematodes—*Heterodera schachtii* (sugar beet cyst nematode), *H. humuli* (hop cyst nematode), *Rhadinaphelenchus cocophilus* (red ring nematode of coconut) and *Ditylenchus destructor* (potato rot nematode); Pathogens—*Fusarium oxysporum* (wilt of garlic), *Claviceps purpurea* (ergot of barley, triticale and wheat), *Botrytis cinerea* (gray mould of wheat, barley and grape), *Phomopsis phaseolorum* (pod and stem blight of soybean), *Puccinia carthami* (rust of safflower), *Ascochyta sojicola* (leaf spot and blight of soybean), *Uromyces betae* (sugar beet rust), *Fusarium nivale* (snow mould of wheat), *Ascochyta pinodella* foot rot and collar rot of pea), *Urocystis iritici* (flag smut of wheat) and *Ustilago tritici* (loose smut of wheat and barley).

(iv) *Germplasm evaluation, characterisation and documentation*

The Bureau handles more than 75 major and minor crops at its headquarters and Regional Stations.

The evaluation of indigenous and exotic germplasm over the years has resulted in the identification of several promising genetic stocks, resistance sources to diseases, insects and nematodes which constitute important gene sources for crop improvement programme.

The characterisation and documentation of data has resulted in the preparation of crop catalogues/inventories on wheat, barley, amaranth, tomato, cluster bean, French bean, winged bean, cowpea, field pea, moth bean, soybean, lentil, *Sesbania*, *Trigonella*, opium poppy, safflower, sunflower, sesame and maize (Paroda and Arora, 1986). The establishment of computer facilities at the headquarters has recently accelerated the process of data documentation and cataloguing.

(v) *Germplasm conservation*

Top priority has been assigned to conservation of genetic resources and the Bureau has recently built facilities for long-term storage of germplasm. Cold store modules, currently operative at NBPGR, hold 76,000 accessions in different crops. Gene bank facility for conservation of over 2,00,000 accessions under long-term (–18 °C) storage is being created presently.

(a) *In vitro-and cryo-preservation*

The recently established National Facility for Plant Tissue Culture Repository at NBPGR is aimed to further strengthen India's germplasm conservation programmes. It lays major emphasis on *in vitro* conservation of clonally propagated plant species and cryopreservation of pollen, recalcitrant seeds as well as small seeded orthodox species in liquid nitrogen (−196°C) and on related aspects of genetic stability using isozyme systems and cytological parameters. Crop priorities for this programme have been determined through critical discussion with leading experts in the country. These include : (a) *in vitro* conservation—tuber/bulb crops (*Allium sativum* and related wild species, *Colocasia esculenta, Ipomoea batatas, Dioscorea* spp.) ; spices and plantation crops (ginger, *Piper nigrum, P. betle, Curcuma* spp.) ; horticultural crops (banana, citrus, papaya, pomegranate, etc.) ; medicinal and aromatic plants (*Rauvolfia serpentina, Tylophora indica, Pogostemon patchouli, Coleus forskohli* and *Coptis teeta*), (b) Cryopreservation—recalcitrant species (cocoa, tea, clove, nutmeg, coffee) ; small-seeded orthodox species (Brassicae, sesame, onion, pearl millet, tobacco) ; pollen (primitive landraces of *Zea mays* from Mexico and Sikkim and other related taxa such as teosinte, *Z. diploperennis, Z. luxuriens, Coix* spp.. *Chionachne* spp., etc).

LINKAGES

(i) *Linkages with ICAR institutes and agricultural universities*

NBPGR has strengthened its linkages with several crop based institutions/multicrop regional institutions, Project Directorates, National Centres and several All-India Coordinated Projects on different crops. The linkages with different agricultural universities in the states and several ICAR centres located in these universities have equally important support and service from NBPGR in germplasm exchange, evaluation and field gene bank establishment. The NBPGR also extends its support for conservation of base collections being held by other institutions and provides facilities for data documentation, cataloguing, etc.

National Bureau of Plant Genetic Resources continues to forge its strong linkages with crop-based institutions like Central Potato Research Institute (CPRI), Shimla; Central Rice Research Institute (CRRI), Cuttack; Central Plantation Crops Research Institute (CPCRI), Kasargod; Central Tuber Crops Research Institute (CTCRI), Trivandrum; Central Institute of Cotton Research (CICR), Nagpur; Sugarcane Breeding Institute (SBI), Coimbatore; and Jute Agricultural Research Institute (JARI), Barrackpore.

NBPGR also caters to the needs of premier research institutions like the Indian Agricultural Research Institute (IARI), New Delhi, other ICAR institutes/centres i.e. Indian Institute of Horticultural Research (IIHR), Bangalore, Central Institute of Horticultural Research for Northern Plains (CIHRNP), Lucknow, National Research Centre for Groundnut, Junagarh, National Research Centre for Soybean, Indore, as well as Project Directorates for wheat, New Delhi, rice

and oilseeds, Hyderabad and pulses, Kanpur; all have direct support from NBPGR in terms of germplasm exchange, collection and conservation of base collections of valuable plant genetic resources. It also serves regional and specific problem-oriented institutes such as the Central Arid Zone Research Institute (CAZRI), Jodhpur and Central Soil Salinity Research Institute (CSSRI), Karnal. Besides, it maintains effective linkages with all the agricultural universities of the country.

National network on horticultural plants in India has been significantly strengthened and expanded. Presently, there are five independent institutes, one National Research Centre and twelve All India Coordinated Research Projects operating in 23 state agricultural universities on horticultural crops. In addition, ICAR Institutes like IARI, New Delhi, NEH Complex, Shillong, CAZRI, Jodh-Pur, NBPGR Regional Stations at Shimla, Jodhpur and Akola, Vivekananda Parvatiya Krishi Anusandhan Shala (VPKAS), Almora and Central Agricultural Research Institute (CARI), Port Blair are also engaged in research on horticultural crops. State agricultural universities and regional centres are working on major and minor fruit crops. NBPGR serves all these programmes in terms of their requirements for exotic as well as indigenous germplasm.

(ii) *Linkages with international organisations*

Bureau continues to forge very strong links with several CGIAR supported International Institutes all over the world. During the past one decade, there has been considerable strengthening of collaborative activities with IRRI, CIMMYT, ICRISAT, ICARDA, IITA, CIP, CIAT, AVRDC and also with IBPGR. Emphasis has been laid, apart from introduction and exchange of elite cultivars/strains, on evaluation of trial material and on development of scientific expertise. A joint collaborative programme for five years is in operation between NBPGR and ICRISAT to carry out collection and the evaluation of the ICRISAT mandate crops (sorghum, pearl millet, chickpea, pigeonpea and groundnut) and for minor millets. Untapped areas will be explored for germplasm collection, multilocation trials will be conducted and joint catalogues brought out. IRRI and CIMMYT have extended their facilities for training of scientists and joint collection expeditions have been organised with IRRI to collect rice from India.

(iii) *Linkages with IBPGR*

National Bureau of Plant Genetic Resources maintains effective linkages with International Board for Plant Genetic Resources (IBPGR), Rome, Italy. IBPGR in the past extended support for conducting short training programmes in exploration and collection activities (1979, 1980 and 1982) and provided fellowships for training of scientists for full one year and short courses at the University of Birmingham, England. Bureau's expertise has also been availed at different times by IBPGR in germplasm collection in Africa and Maldives. Recently, IBPGR-NBPGR jointly undertook an expedition in Kenya, Sudan and Ethiopia for sorghum germplasm. IBPGR has recently signed a Memorandum of Understanding (MOU)

with ICAR for better cooperation and coordination. IBPGR has also designated NBPGR Gene Bank as the world repository for over a dozen economic crop plants such as Asiatic *Vigna* species, cucurbits and egg-plant.

IBPGR has decided to establish its regional office for South and South East Asia at NBPGR Campus, which will further strengthen these interactions. India has also extended its support to FAO Commission on Plant Genetic Resources and has given an undertaking for the free exchange of germplasm for research purposes.

QUARANTINE REGULATIONS AND INTERNATIONAL EXCHANGE

While realising the importance of exchange of seed/planting materials, it is also necessary to view critically the problems associated with exchange particularly in view of the quarantine needs. Many crop species do not produce seeds and are propagated vegetatively. When these vegetative propagules are exchanged, the transfer of several associated pathogens and pests cannot be over-ruled and this could result in considerable risks, if stringent phytosanitary and quarantine regulations are not followed (Paroda et al., 1987).

It is well recognised that hasty and uncontrolled introduction of germplasm material has the inherent risk of inadvertently introducing new pest/disease problems. The required quarantine safeguards may be divided in two groups (a) legal safeguards and (b) functional safeguards.

(a) *Legal safeguards*

Under the legal safeguards, import of seeds, plant propagules and other planting materials in India is regulated by the rules and regulations contained in the Destructive Insects and Pests Act (DIP Act) of 1914. This Act has been amended/corrected a number of times since then, the latest amendment being Plants, Fruits and Seeds (Regulation of import into India) Order, 1984, which became operative on June 24, 1985.

(b) *Functional safeguards*

The Directorate of Plant Protection, Quarantine and Storage is basically responsible for implementation of quarantine safeguards in India and for this purpose plant quarantine and fumigation stations have been established at all the international airports, sea ports and land route stations. The incoming material is inspected, fumigated or otherwise disinfected before release. Quarantine green house, screen house facilities are also available for post entry isolation growing at some of these stations. The stations under the Directorate handle bulk imports of commerce and seed/planting materials imported by private organisations/individuals. NBPGR, New Delhi is the designated nodal agency of the Government of India for the exchange of germplasm material of all agri-horticultural and agri-silvicultural crops for research purposes. To fulfil its quarantine obligations, NBPGR created a separate Division of Plant Quarantine with its constituent units

of Entomology, Nematology and Plant Pathology with laboratory facilities and experienced man power. NBPGR has developed methods, procedures and techniques for detection and salvaging of imported seed and planting materials (Ram Nath et al., 1987). A regional station at Hyderabad caters to the needs of plant quarantine in South India and also serves ICRISAT for its exchange of germplasm.

Required modifications in the quarantine regulations

The Indian Destructive Insects and Pests Act (DIP Act), does not have any specific recommendations or guidelines on the examination and release of materials in tissue culture (*in vitro* cultures). Hence, there is a need to consider the following points for eventual modifications in the DIP Act based on experience gained on the subject.

(i) The consignment should be accompanied by an additional declaration that the material under tissue culture has been developed from tissues free from viruses, viroids, mycoplasma and fungi and bacteria (mentioned in the text).

(ii) After preliminary quarantine examination, it should be grown in glass house/net house for one crop season to make sure that the plants developing from the plantlets are free from organisms which cannot be eliminated through tissue culture.

Some other points which merit consideration for inclusion in the DIP Act are :

(a) Germplasm material should be introduced in the form of seeds, unless vegetative propagation is necessary.

(b) For vegetative propagation, non-rooted material should be preferred over rooted plants.

(c) Consignments of vegetatively propagated material should be small. Each variety or species should be represented by a few tubers, cuttings or scions.

(d) If rooted plants are imported, cuttings derived from such plants only should be released instead of the original plants themselves, which should be destroyed.

PLANT BREEDERS' RIGHTS

The expanding horizon of patent rights in plant breeding is leading to a state of polarisation in the field of conservation and utilisation of plant resources. The adoption of Plant Breeders Rights has stimulated private plant breeding as there is a growing private concern to incorporate genetic diversity in the product/commodity being patented. Thus, the useful characteristics such as disease/pest resistance and adaptations to specific environments, found in material available in the centres of diversity located in the developing countries can be incorporated into a patented variety by the developed countries. The varieties protected by such rights earn royality on the sale of their seeds. These are thus not available for free exchange. Further, in opting for patented varieties, farmers are paying

for the seed technology and not the raw material. Many seed companies are owned by chemical firms, which can fail to incorporate a certain resistance so that the farmer is obliged to buy their products to protect his crops leading to a further increase in the cost of growing high-yielding varieties.

In India, more recently, several private national seed companies have emerged in the seed production business. A few of them also have an international network. Both kinds of commercial companies have been importing material from abroad (Table 1), through NBPGR.

TABLE 1 : IMPORT OF PLANT MATERIAL BY PRIVATE SEED INDUSTRY

S. No.	International/National seed company	Crop varieties/ accessions imported
1.	Cargill South-east Asia Ltd.	*Helianthus* spp. (3 varieties)
2.	Coromandel Indag Products India (P) Ltd.	Tomato (15 varieties)
3.	Pioneer Seeds Co. Ltd.	*Zea mays* (10 samples), *Sorghum bicolor* (91 accessions), Sunflower (30) and *Oryza sativa* (12)
4.	Mahyco Seed Company	Maize (405 accessions), *Triticum* spp. (195 samples) and Sunflower (4 varieties)
5.	Nath Seed Company	Tomato (23), Sunflower (40), Maize (9) and *Gossypium* spp. (7)
6.	Hindustan Lever Ltd.	New oil yielding species; Oil palm, *Macauba caryocar*, etc.
7.	Godavari Plywood Ltd.	*Eucalyptus* spp. (6), *Acacia* spp. (3), *Casuarina cunninghamiana* (1) and *Sesbania formosa* (1)
8.	Tata Energy Research Institute	*Acacia* sp. (10), *Gliricidia sepium* (37) *Oryza* spp. (14) and *Eucalyptus* spp. (5)
9.	Wimco Seedlings Ltd.	*Brassica oleracea*, *Lycopersicon esculentum* (27) and *Brassica oleracea* (12)

FAO COMMISSION ON PLANT GENETIC RESOURCES

Recently, FAO member nations, with reservations by some countries, adopted a resolution on an International Undertaking on Plant Genetic Resources with the purpose of putting into inter-governmental hands, control of the promotion of efforts in exploration and collection of plant genetic resources, adoption of

legislative action to preserve, evaluate and document genetic material, to control the access to genetic resources and permission for their bonafide export, the international cooperation and improvement of capabilities in developing countries, formulation of global information system and to provide a stimulus for *in situ* conservation. To implement the undertaking, FAO has established a commission on Plant Genetic Resources in 1987, whose membership is open to all FAO member nations and associate members. The Commission is composed of about 100 countries. The global network may assist developing countries in conserving and utilising genetic resources and in their free exchange.

Also, a proposal was made to institute a set of farmer's rights for the farmers in the "Centre of Origin" countries to offset the impact of the breeder's rights in the developed countries. This issue is gaining importance since genetic engineering enables us to transfer genes accross several barriers. Wild species of economic plants occur primarily in the developing nations. Unless considerations of human welfare and sustainable development are coupled with considerations of commerce, competition and confrontation may replace cooperation in plant sciences. This step is essential in international cooperation, in the sustainable management of the biosphere and geosphere including crop plant diversity.

FUTURE THRUST

The role of NBPGR in coordinating activities on plant genetic resources has increased tremendously over the past one decade. To meet the growing demands of the breeders for elite material, cultivars and wild species and to share international commitments with the IARCs (IRRI, CIMMYT, ICARDA etc.), the flow of genetic resources has been considerably high. There is a dire need now to strengthen and create Plant Quarantine infrastructure commensurate to the flow of material for ensuring quarantine safeguards involving the concerned crop institutes/projects, Directorate of Plant Protection, Quarantine and Storage, agricultural universities and a few regional stations of the Bureau. This is particularly required for post-entry quarantine facility. In this context, an off-shore quarantine facility is being established at the newly proposed station of the NBPGR at Port Blair, Andaman and Nicobar Islands. As for maintenance of working collections, national responsibilities are being defined and crop curators/institutions/centres are being identified. The responsibility of maintaining base collections for long-term preservation of genetic resources will rest with NBPGR. Computer facilities for data documentation will also be generated at Bureau's regional stations/other centres with NBPGR providing the required coordination in this regard. Also, the need for a Crop Advisory Committee is greatly felt.

Highest priority in national context is also attached to the establishment of an efficient facility for preservation of genetic diversity. The building of the National Germplasm Repository will be constructed nearer the present location of the Bureau with all modern equipment and gadgets, apart from strengthening the present infra-structure wherein the long-term storage modules installed

have a capacity to store about 200,000 seed samples. Such facilities for medium-term seed storage are also to be generated at a few selected stations of the Bureau and other centres including crop institutes and agricultural universities. The Indo-US project on strengthening the genetic resources activities has laid much stress and emphasis on these aspects in generating/strengthening the necessary infra-structure, apart from training of personnel and visits of consultants/scientists both within the country and abroad for better and more effective linkages. In this context, it is gratifying to note that the Government of India/ICAR, has set up a National Policy Planning and Review Committee on Plant Genetic Resources with members from the CSIR, DOEn, ICAR, agricultural universities, Directorate of Plant Protection, Quarantine and Storage, so as to coordinate and promote the national endeavour.

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